Reclamation and Restoration of Settled Landscapes

September 27th – 30th, 1998
Markham, Ontario

PROCEEDINGS

Hosted by the

SOCIETY FOR ECOLOGICAL RESTORATION
Ontario Chapter

and the

CANADIAN LAND RECLAMATION ASSOCIATION

in conjunction with the
CLRA 23rd ANNUAL MEETING

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Society for Ecological Restoration, Ontario Chapter
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Hosler, Kevin R. and E.N. Drake
"A TEST OF PLANT-AIDED PETROLEUM HYDROCARBON DEGRADATION"
on page three

The factors were tested at two levels each (i.e., either present or absent), and can be summarized as follows:

Treatment #1 **Contaminated soil** ..... **(no factors)**
Treatment #2 **Contaminated soil + grass** ..... **(factor "A")**
Treatment #3 **Contaminated soil + BuRIZE™** ..... **(factor "B")**
Treatment #4 **Contaminated soil + fertilizer** ..... **(factor "C")**
Treatment #5 **Contaminated soil + grass + BuRIZE™** ..... **(factors "AB")**
Treatment #6 **Contaminated soil + grass + fertilizer** ..... **(factors "AC")**
Treatment #7 **Contaminated soil + BuRIZE™ + fertilizer** ..... **(factors "BC")**
Treatment #8 **Contaminated soil + grass + BuRIZE™ + fertilizer** ..... **(factors "ABC")**

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Canadian Land Reclamation Association
Box 61047, Kensington P.O.
Calgary, Alberta
T2N 4S6

Society for Ecological Restoration, Ontario Chapter
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Trent University
Peterborough, Ontario K9J 7B8

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AN ECOSYSTEM APPROACH TO MANAGEMENT: A CONTEXT FOR RESTORATION AND RECLAMATION

Paul A. Gray

**Natural Heritage Section, Lands and Natural Heritage Branch,
Ontario Ministry of Natural Resources, 300 Water Street,
Peterborough, Ontario, K9J 8M5, Canada.**

ABSTRACT

Recognition that the cumulative effects of human activity require mitigation is one of many factors contributing to a global call to change the ways people think about and work the Earth – a call to repair what is broken and degraded and to maintain and/or protect what works. Accordingly, societies around the world are exploring the type of change required and the ways of implementing it. Routinely, this change is expressed through the lofty concepts of sustainable development, ecosystem management, and ecosystem health – three prominent catch phrases that now permeate the scientific and popular media, and form the basis of a growing number of private sector, government, and academic programs. In a state of constant redefinition and reconfiguration, these words generate a variety of responses (e.g., inspiration, anger, enlightenment, and confusion) from people who must interpret their meaning and translate their intent into tangible action in, on, and above Earth's landscapes and waterscapes. Can the concepts denoted by these words be described in practical terms and usefully applied? If so, how are they related? This discussion paper briefly explores the definition and application of these concepts as a context for programs (e.g., restoration and reclamation) designed and implemented in support of efforts to keep Earth's landscapes and waterscapes working.

Introduction

Organisms derive their existence from the Ecosphere, and humans are no exception. People depend on Earth, her processes and resources to survive. But unlike the other 10-30 million species, humans have evolved the ability to transform unprecedented numbers and amounts of ecosystem services, products, and experiences. Insignificant and isolated at first, human endeavour had little influence on the Ecosphere, but the rates at which, and methods by which, people currently consume resources are jeopardizing ecospheric health and the long-term future of humankind. In fact, the transformation of ecosystem services and products (energy and matter) has been the single defining objective of human existence. For example, we now co-opt the organic equivalent of about 40% of the present net primary production in terrestrial ecosystems each year (Vitousek et al., 1986). It appears that we have begun to eclipse the finite capacity of ecosystems to cope with human-induced change (Rees, 1990).

Many agree with the need to recast the ecospheric-human relationship. And over the last 20 years, jurisdictions around the world have acknowledged that the altering power of unchecked human endeavour needs to be brought into balance with Earth's metabolism. For example, global reciprocity was provided some tenure as an element in the controversial and much debated concept of sustainable development that was articulated by the World Commission on Economic Development in its report, "Our Common Future" (WCED, 1987). Predictably, the popular, scientific, and agency literature has exploded with ideas, guidelines, and recommendations proposed to assist in the quest for initiatives (e.g., ecosystem management) that will lead to a

new ecospheric-human relationship. This discussion paper briefly examines the definition and application of sustainable development, ecosystem management, and ecosystem health as a context for programs (e.g., restoration and reclamation) designed and implemented to attain and/or maintain ecospheric-human balance.

Sustainable Development [Sustainable Living]

Sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). It is an unfortunate catch-phrase. To sustain is to keep, to preserve, to continue to maintain something (Shields et al., 1993). Generically, the word is linked to the idea of well-being, but carries a different meaning for each person, a function of individual values, perspectives, education, and life-experiences. And when linked with "development" in reference to ecospheric well-being, its meaning is further clouded by the conflicting concepts and paradoxes that result.

Some people identify more with the "sustainable" part and work in support of efforts devoted to ecological and social transformation. Others identify with "development" and interpret it to mean a redefined version of the *status quo* (Wackernagel and Rees, 1996). From this perspective, the WCED's definition (and its derivatives) has been challenged because, among other concerns, it advances the age-old anthropocentric and utilitarian perspective that underwrites a recipe for perpetual growth (e.g., industrial development), continued deterioration of ecosystems, and loss of constituent biological assets (Dovers and Handmer, 1993; Pearce et al., 1989; Robinson, 1993; Robinson et al., 1990; Willers, 1994). But is it really a question of definition? Costanza and Patten (1995) suggest that much discussion and debate is misdirected because people continue to cast the problem as a definitional one when in fact it is more an issue of prediction – a prediction about what will last (given a prescribed suite of human activities) and achieving consensus (reconciling the values that make sustainable action possible) on what we want to last.

Many of the questions that have emerged from the examination of, and associated debates over, sustainable development are about values and beliefs that ultimately guide human behaviour in the finite ecosystems that provide the products, services, and experiences required for life – sustained life. While admittedly anthropocentric, the idea of "sustainable living" is more tenable than "sustainable development" if for no other reason than the fact that it does not carry a connotation of "development" as the principal driving force. Under the auspices of a reconfigured suite of values, it signifies balance – balance between the people who draw from and use Earth's processes and resources to survive and the ecosystems of which they are a part. Accordingly, sustainable living is envisioned as an Ecosphere filled with healthy ecosystems and healthy people -- a condition or state of ecospheric-human balance that society predicts can be attained and maintained.

While the concept of sustainable living can serve as the basis for a vision of (a prediction about) the future, it does not provide us the means or the path to get there. Despite the limitations of the original concept(s) of "sustainable development," the associated debates have highlighted the need to intensively and extensively examine human conduct in the Ecosphere. For example, in the decade following publication of "Our Common Future," the literature has been populated with reports on initiatives that examine the notion of culture as the primary cause and possible cure for Earth's ecological ills (one of the paradoxes), managing for uncertainty, intergenerational and intragenerational equity, individual versus collective interests, empowerment, the adaptive ability of humans and their institutions to cope with change, and the sustainable scale of the human economy relative to the life-support system(s) upon which that economy relies (i.e., what are the ecospheric limits to growth?). But how do we transform these issues and ideas, and any decisions about them into tangible action in,

on, and above Earth's landscapes and waterscapes? An ecosystem approach to management is one path available to us.

The Concept of an Ecosystem Approach to Management

Fundamentally, an "ecosystem approach" is based on the idea that if humans subscribe to and apply an appropriate set of values and are equipped with the required knowledge and tools, they can protect and maintain ecosystems, derive a quality existence from them and simultaneously ensure that opportunities for future generations are retained (Gray et al., 1996). An ecosystem approach is an adaptive process that employs a suite of integrated programs to care for Earth's natural assets by managing our relationship with the other components of ecosystems and ensuring that our perceptions, values, and behaviours work in support of ecosystem function. It is an encompassing process that captures the range of cultural, social, economic and ecological values that ultimately define human-ecosystem relationships (Fig. 1). An ecosystem approach to management is a method that can assist committed people in their efforts to keep the landscapes and the waterscapes working (Merriam, 1994) – an absolute requirement for the attainment and maintenance of healthy ecosystems and healthy people.

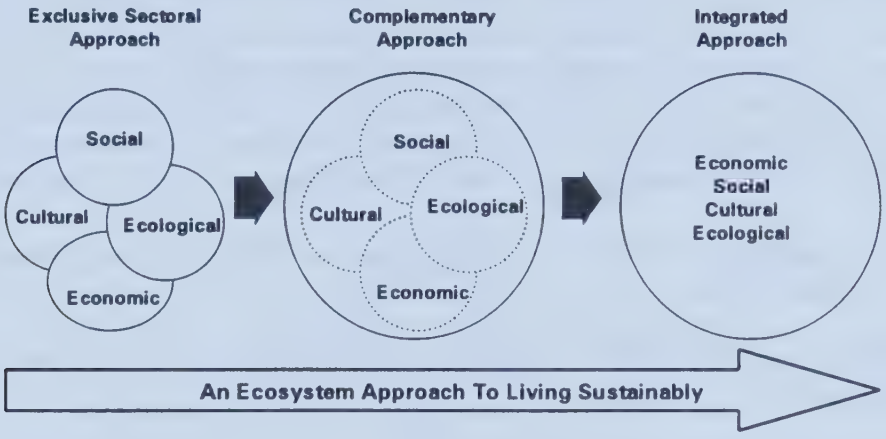


Figure 1. Sustainable living requires that society move from an exclusive sectoral approach to valuing and using natural assets to an integrated approach.

"Management" is a sweeping, generic term for the cadre of tools and techniques we use to meet our objectives and attain our goals. It is a controversial aspect of human endeavour, often a focal point of conflict, because as traditionally applied it has failed to account for the range of values and philosophies held by the variety of peoples who comprise Earth's cultures and societies. For example, the neo-classical utilitarian's approach to management is radically different from that of the emergent eco-centrist's perspective. In addition, the term often is used to imply that people understand the complex nature of ecosystem composition, structure, and function when, in fact, we do not. Is ecosystem management possible? No, not now, or in the near future. But an ecosystem approach to management is -- an encompassing endeavour that:

- captures the range of cultural, social, economic, and ecological values that ultimately define ecosystem-human relationships;

- requires decisions be made in the context of ecosystems as holistic entities with many natural assets, not individual resources;

- is sponsored by flexible, adaptive, accountable, and learning-oriented institutions;
- is participatory and knowledge-based;
- is dynamic and adaptive whereby the impacts (positive-neutral-negative) of human actions are identified, monitored, and constantly evaluated against prescribed measures of healthy ecosystems and healthy people; and
- results in a balanced spectrum of human activities (ranging from complete protection to active manipulation of natural assets) that are at least impact-neutral.

How do we organize ourselves to embrace and employ an ecosystem approach to management? Strategic, tactical, and "on-site" management plans developed in support of an ecosystem approach fill our bookshelves and our hard drives. They provide thousands of useful ideas and recommendations that implicate all sectors of society. But many are limited by organizational frameworks that constrain a society's ability to adequately cast natural assets (including humans) within an ecological context, and identify, explore, and wisely employ the full spectrum of social conditions and forces that determine human behaviour and impact ecospheric function. Building on the work of others (e.g., Christie et al., 1986; Gerlach and Bengston, 1994; Great Lakes Research Advisory Board, 1978; Grumbine, 1994; Kaufman et al, 1994; Lee, 1993; Robinson et al., 1990; Rowe, 1991, 1994), Gray et al. (1995) suggest that effective natural asset planning can be accomplished by commitment to, and application of, a unifying framework comprised of three themes and nine interrelated modules (Fig. 2):

A. An ecologically meaningful spatial and temporal context in which to manage human activity in the ecosphere. It requires that we:

1. define and describe Earth's ecosystems in-space-in-time and align our decisions and actions accordingly.

B. The appropriate enabling mechanisms, including:

2. a philosophy and corresponding suite of societal values that enable natural asset managers to take effective action;
3. institutional cultures and structures that sponsor proactive and integrated programs; and
4. programs involving all sectors of society as partners and participants in decision-making processes.

C. The appropriate suite of tools to help us understand Earth and to guide human behaviour in, on, and above her landscapes and waterscapes. Accordingly, society must sponsor:

5. useful data and information gathering and management programs (e.g., research, inventory, monitoring, and assessment) to advance our knowledge of ecospheric function and human impacts;
6. knowledge dissemination through life-long learning opportunities that are accessible and current (i.e., education, extension, and training programs);
7. strategic thinking and planning to identify, establish, and modify short- and long-term direction;

8. policy, legislation, and regulation to guide society in adoption and attainment of sustainable lifestyles; and

9. in-situ and ex-situ planning and management techniques designed to protect the pieces, the patterns, and the processes.

The importance of a commitment to care for Earth's natural assets can not be overstated – it is a critical element of any successful initiative. But commitment is meaningless in the absence of an integrated, unified, and practical protocol for action. The modules provide a basis to identify the appropriate questions and organize the suite of programs (e.g., ecosystem description, research, inventory, policy development, and restoration and reclamation) required for implementation. Given the space limitations of this paper, description and analysis of each module is not possible. While all modules are important, establishment of an ecologically-meaning spatial framework (a context) is a fundamental requirement for successful implementation of an ecosystem approach to management. Accordingly, the following section is devoted to the definition and description of ecosystems.

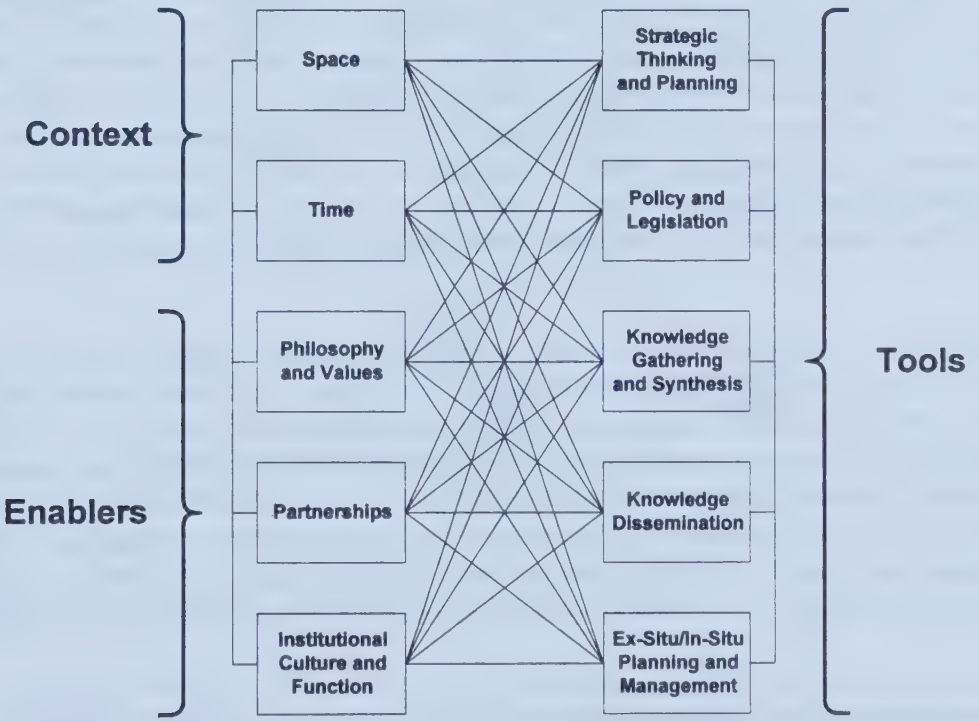


Figure 2. An ecosystem approach to management framework. The modules are linked and often employed simultaneously or in unison to develop and deliver ecologically-based programs (e.g., restoration and reclamation projects).

Ecosystem Defined

An ecosystem approach to management is based on the fact that Earth operates as a series of interrelated systems, within which all components are linked (Bailey, 1996). Rowe (1961) defines ecosystem as a "topographic unit, a volume of land and air plus organic contents extended areally over a particular part of the earth's surface for a certain time." And as the fundamental context for natural asset management, ecosystems

are used as bounded, geographic units of the landscape, waterscape, and airscape that include all natural phenomena. Rowe, Bailey, and many others, argue that an ecosystem is a definable entity that has currency as a context in which to pursue sustainable living objectives – it is a recognizable chunk of Earth space in which the flow of energy and the transformation of matter in-space-in-time creates networks of organisms (such as plants and animals, including humans), atmosphere, rock, soil, and water, interacting with each other and with other ecosystems.

Why use an ecological perspective, a relatively new and little tested technique, as the spatial context within which to pursue sustainable living objectives? After all, over the last few thousand years, societies throughout the world have invested significant resources (and spilled much blood) in the creation of spatially-based jurisdictional/administrative (e.g. country, province, district, and township) and thematic (e.g., mineral resources, species habitat, protected areas, and forested land) units to define their relationships with other societies and Earth's natural assets. The simple fact is that ecosystems have sponsored life for 4.6 billion years. And no society, however well endowed with knowledge and technology, can escape the fact that life derives from the Ecosphere and her constituent ecosystems – life does not equal organisms; life equals organisms plus the ecosystem(s) upon which they depend (Rowe, 1992a). And sustained life, through appropriate long-term management of human activities in, on, and above Earth's landscapes and waterscapes, depends on our success at identifying the inter-relationships between the natural assets that comprise each ecosystem – understanding ecosystem composition, structure and function (Fig. 3). In contrast to jurisdictional and thematic units, the ecosystem provides an integrating framework within which natural asset managers can work to address the spectrum of cultural, social, economic, and ecological factors and forces. And now that human actions have created significant impacts of continental and global proportions, an ecological context is increasingly required to scope out and understand the issues, establish partnerships, and design appropriate management programs.

Ecosystems can be very large (e.g., the Ecosphere is the largest earthly ecosystem) and very small (e.g., a pond), where the smaller ecosystems fit into the larger ecosystems. This hierarchical organization has been described as "successively encompassing levels of interacting components or units" (Grobstein, 1974) that constitute a system of "discrete interactive levels" (Pattee, 1973). An hierarchical approach helps us perceive complex systems by dividing them into understandable levels. Natural asset managers must be able to make decisions about human activities in ecosystems of all sizes, which requires that they know the location of ecosystem boundaries. The task of spatially and temporally delineating and describing ecosystems is called ecosystem classification (e.g., in Canada, the national program is referred to as Ecological Land Classification).

Each ecosystem is unique and complex, the boundaries of which exist as a gradient between neighbouring systems. This presents natural asset managers and users with a problem. How can we hope to understand ecosystems in all their complexity and diverse shapes and sizes if they are all different? Fortunately, advances in ecological theory, analytical techniques, and spatial technologies now permit managers to apply integrated and interactive ecosystem delineation tools and techniques (see Rubec [1992] and Sims and Uhlig [1992] for a summary of some programs). While not perfect by any means, scientists and managers have identified criteria and rules with which to draw lines on maps and photographs, build scale models, and draw pictures – to define and describe ecosystems as recognizable chunks of space-in-time (Fig. 4). The criteria are based on the factors and forces that create and shape ecosystems (see Fig. 3). For example, the boundaries of large ecosystems can be delineated by integrating climate and landform patterns while smaller ecosystems can be identified through examination of soils and vegetation patterns.

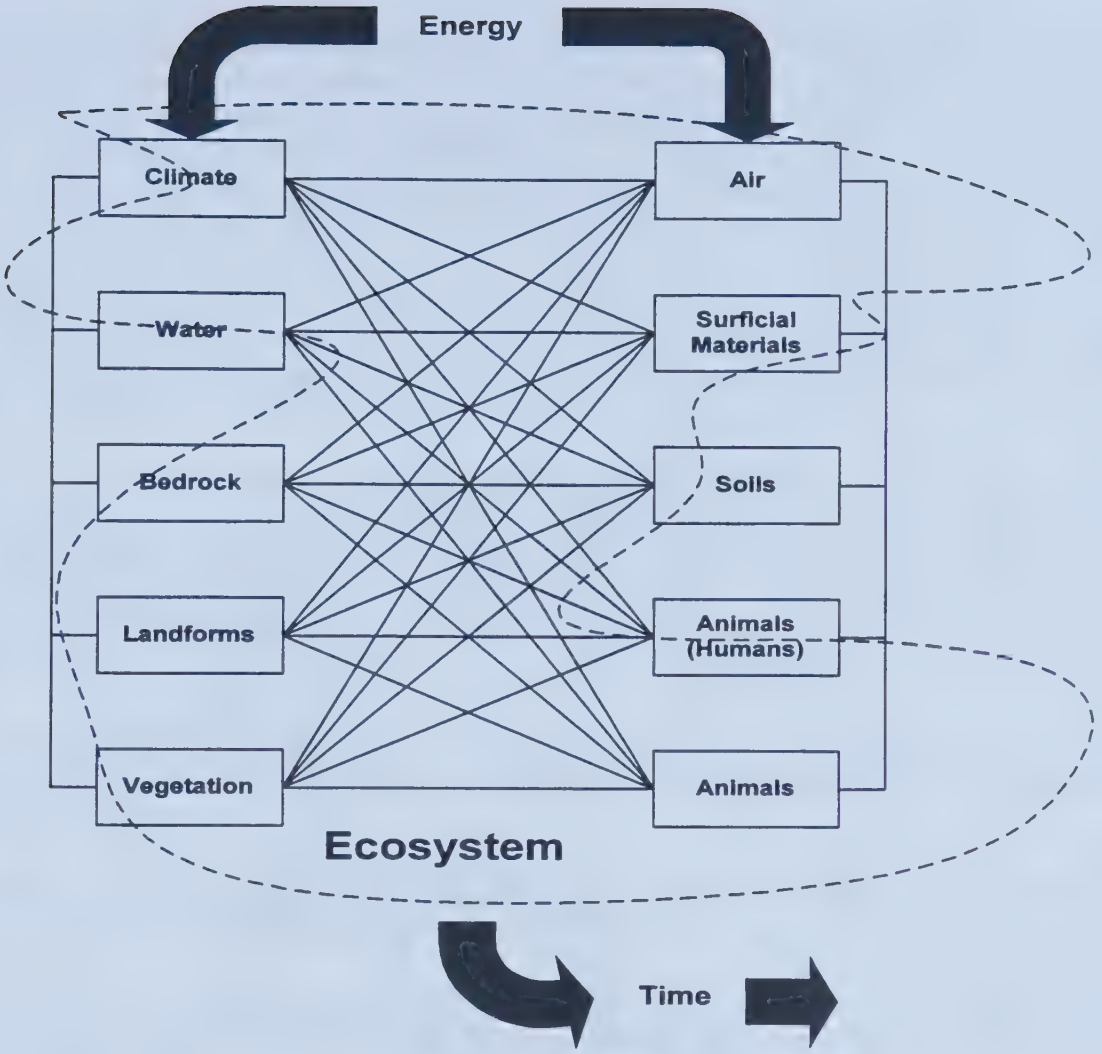


Figure. 3. The forces and factors that create and shape ecosystems.

The Concept of Ecosystem Health

A principal indicator of sustainable living is ecosystem health. But what is it? In its simplest terms, health measures system performance through the behaviour (function) of its parts (composition and structure) (Costanza et al., 1992). Costanza and Patten (1995) suggest that a system is sustainable if and only if it persists in a nominal behavioural state as long or longer than its expected existence time -- that it attains its full expected life span within the nested hierarchy of systems in which it is embedded. While most people immediately and correctly equate ecosystem health to lots of indigenous plants and animals relative to the ecosystem(s) in which they evolved, abundant clean water, forests, and wetlands, there is more. Humans are an important part of the Ecosphere. Rapport (1995) characterizes ecosystem health as a measure of the level of distress in the ecosystem, the ecosystem's resilience to perturbation, the ecosystem's ability to sustain itself, the degree to which an ecosystem's function does or does not impair the healthy functioning of adjacent ecosystems, and the extent to which the ecosystem supports healthy human communities. From this perspective, ecosystem health is an integrated combination of cultural health, social health, economic health, and ecological health.

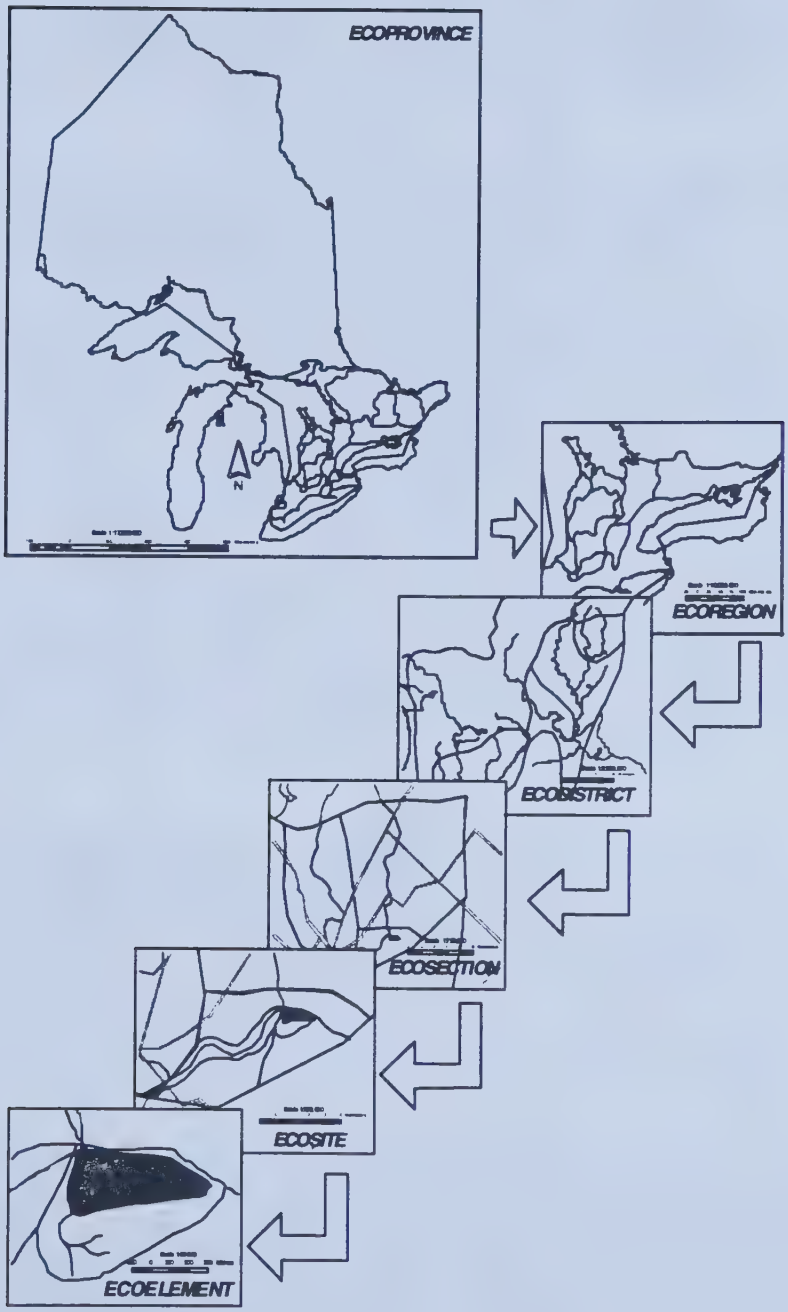


Figure 4. Using the federal Ecological Land Classification terminology, this spatial simulation model demonstrates how ecosystems of varying size and shape are related to each other in ladder-like levels. Use of this type of classification system allows natural asset managers to design and deliver programs within an ecologically meaningful spatial framework.

To what state or condition of ecosystem health do we aspire? Ecosystem health has no operational meaning unless it is defined in terms of a desired state or condition for that ecosystem (Lackey, 1994) – a condition or state that we predict can be achieved and sustained. For example, society may elect to maximize opportunities for ecotourism, or sustained yield of timber, or agricultural products, or all of these. Each prescription results in a unique ecosystem (Lackey, 1994). Similarly, Rowe (1992b) asks to what extent should we maintain natural (areas designated for preservation), semi-natural (areas in which resources are managed for sustained use), artificial (devoted to high input, intensive use such as farming and forestry) ecosystems, and to what extent do we establish restoration and rehabilitation programs for entire ecosystems? These questions are, of course, critical to visioning, establishing goals (e.g., healthy ecosystems and healthy people), and setting management targets. And the answers are, in large part, based on a commitment to, and decisions respecting attainment of, a prescribed level of ecosystem health.

Societies in many jurisdictions have devoted considerable effort (has it been enough?) to the study and application of ecosystem health in the last decade (e.g., Cairns, 1994; Costanza et al., 1992; Gray, 1992; Gray et al., 1992; Rapport, 1989, 1992, 1995; Regier, 1993; Schindler, 1987; Steedman, 1994; and Woodley et al., 1993). And while integrated programs to measure and monitor cultural, social, economic, and ecological health have begun to emerge, this discipline is in its formative stages. Steedman (1994) maintains that we can not expect the discipline to:

- specify unambiguous, routine criteria for interpretation of observations, because benchmarks for high and low ecosystem health are based on a complex mix of quantitative and qualitative data and information in a scientific and cultural context;

- provide a direct measure of ecosystem health because managers always will be required to choose and justify surrogate measures to index ecosystem health; and

- substitute for detailed information about specific ecosystem features because as consumers of natural resources, we always will need to collect, interpret, and communicate knowledge and information describing things that are important to us.

Given that simple, heuristic methods to measure and monitor ecosystem health are not likely to emerge as management tools in the near future, what do we do? First, we must recognize that the unique nature of ecosystem composition, structure, and function, and the variety of human activities in each ecosystem requires that health assessments and associated management prescriptions (including restoration and reclamation projects) be unique as well. Second, we must use the knowledge and the tools available to us. Through past and ongoing (cumulative) knowledge-gathering and syntheses (ecological espionage), we have access to a variety of indicators (e.g., presence/absence, abundance, and/or distribution of species and habitats of selected species; soil loss; soil compaction; air quality; toxic chemicals and their impacts; and human health conditions) that provide us some ability to establish targets and recognize existing and potential problems. Third, societies must support the required research and knowledge/technology transfer needed to advance ecosystem health as an important aspect of an ecosystem approach to management.

Summary

Human societies have elected to intensively and extensively use the products, services, and experiences provided by Earth's ecosystems. Through conscious and/or accidental decisions, we have significantly modified, and continue to modify these landscapes, waterscapes, and airscapes. Most people now live in

ecosystems that have been degraded and impaired to some degree. And societies throughout the world continue to accumulate natural debt to which the Ecosphere has begun to respond. Are we listening? Ecospheric-human balance is inevitable, one way or the other. We can elect to follow the difficult and perilous path by maintaining the *status quo*, or we can pursue sustainable lifestyles that at minimum support efforts to ensure protection and repair balances degradation and destruction.

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ABANDONED PIT AND QUARRY SITES: LIVING EXPERIMENTS

Mark H.R. Browning

Wildlife and Natural Heritage Sciences Section
Ontario Ministry of Natural Resources
Peterborough, Ontario

ABSTRACT

The Ministry of Natural Resources' pit and quarry rehabilitation research has concentrated on determining the potential that extraction sites have to support different types of wildlife communities and identifying the critical factors for success in the establishment of specific habitats or ecosystems.

Important sources of information for this research are the numerous abandoned extraction sites scattered across southern Ontario. These can really be considered as living experiments that were begun at the time of abandonment.

Botanical surveys are being carried out at a variety of such abandoned pit and quarry sites in southern Ontario. Randomly located transects and quadrats on these sites provide a description of vegetation patterns. Associated physical variables such as hydrology, topography and soil characteristics are also measured . These are being correlated with the plant patterns to suggest underlying mechanisms.

Initial results from this study are showing that a wide variety of habitat types are possible. Developing marsh, fen, swamp, alvar, and prairie ecosystems have all been found on old extraction sites. Some examples of these are described and the important environmental factors controlling their development discussed.

Finally, data from current field trials set up to test techniques for speeding these natural regeneration processes are presented with emphasis on establishing tallgrass prairie and red oak stands.

Introduction

While there is a fair amount of information and knowledge regarding rehabilitation of extraction sites to agricultural or recreational types of after-uses (Yundt and Augaitis 1992; Mackintosh and Hoffman 1985), there is very little available describing methods to be used in pits and quarries for the establishment of different types of natural communities such as grassland, prairie, wetland or upland forest. With ever increasing interest by the public, industry and government in pursuing this type of rehabilitation, there is a need to determine what factors and processes are involved in naturalisation and what procedures can be developed to facilitate or speed natural regeneration. At an Aggregate Resources Research Workshop, the top research strategy recommended by the rehabilitation group was to "Document and assess previous rehabilitation efforts for extent of naturalization and integrity of ecological function" (Fraser and Ward 1995).

Few extraction sites exist in Ontario that have been deliberately restored to some form of defined native historic ecosystem and most of these are very new with little time to develop structure and function. Fortunately (for this research), there are numerous abandoned pits and quarries across southern Ontario, many having over 30 years of naturalization since abandonment. These are the "living experiments" that can be tapped into, to discover the potential of aggregate sites to become good wildlife habitat. More importantly, these sites provide

clues as to what environmental conditions should be worked into the rehabilitation plans of current and future licensed extraction sites to enable the establishment of a given type of ecosystem or habitat.

The objectives of this study are threefold: 1) to determine the types of ecosystems possible on extraction sites; 2) to identify the critical factors for success in the establishment of these ecosystems; and 3) to develop tools and techniques to facilitate or speed these naturalization processes.

For the third objective this paper will report on some results from a tree shelter experiment for red oak (*Quercus rubra*) establishment and a tallgrass prairie seedling experiment. The red oak experiment looked at the influence of two tree shelter types and two different weed control treatments on red oak survival and growth in comparison to open grown seedlings. The tallgrass prairie experiment compared the growth of 8 native prairie species either planted as plugs or sown as seed and the impact of two different cover crops on both plugs and seed.

Methods

Vegetation Sampling of Abandoned Extraction Sites

The length of each site (x) in meters was measured along one of the long pit or quarry faces. Transects across a site were located by randomly selecting numbers between zero and the site length x. Numbers were chosen until 2.5% of the distance x had been sampled. Transects were run across the width of a site at right angles to the first line. The length of each transect (y) was measured and quadrats to be sampled were located by randomly selecting numbers between zero and the transect length y. Numbers were chosen until 10% of the distance y had been sampled.

A $1M^2$ quadrate frame, divided into twenty-five 20cm x20cm squares, was assembled around the vegetation at each quadrate location. Frequency scores out of 25 were recorded for all plant species, including bryophytes and lichens, which had above ground parts extending into the quadrate. This was done for all plant parts between ground level and 1 meter above ground and then repeated for plant parts of all species overhanging the quadrate between 1 and 2 meters, between 2 and 3 meters, and over 3 meters above ground to get an estimate of the vertical structure of the community.

Abiotic Measurements Taken at Abandoned Extraction Sites

A frequency score out of 25 was also given to certain abiotic features in each quadrate including: four diameter classes of stones, exposed solid rock, bare ground, fallen woody debris, and standing or flowing surface water. Other physical measurements were taken at each quadrate including: slope angle, slope aspect, height above the water table, mean and variability in depth of soil organic layers, mean and variability in total substrate depth to bedrock (quarries only), presence of marl, mean and variability in depth of surface water. Specific notes were also made on recent disturbances and on the relative location of the plot. A composite soil sample of the top 10 cm (or less if depth to bedrock was < 10cm) was taken from 5 sampling locations within each quadrate. Soils were measured for pH, texture, organic content, total N, extractable P, and exchangeable Mg, Ca and K. Site level measurements included years since site abandonment (determined by historic air photos, reports, and knowledge of landowners) and a scoring of the type and extent of surrounding land uses.

Data Analysis

Vascular plant species encountered in the quadrates at each site were used to calculate a mean coefficient of conservatism (C) and a floristic quality index (FQI) using the Floristic Quality Assessment System for

Southern Ontario (Oldham et al. 1995). This system assigns a numerical value between 0 and 10 to each species based on it's habitat fidelity or specificity. Species from a wide variety of plant communities, including disturbed sites score low whereas species found only in a narrow range of conditions with low tolerance to disturbance score a 9 or 10.

Plant frequency data and corresponding abiotic data are being examined using Canonical Correspondence Analysis (CCA). This is one of a group of multivariate techniques used to detect the main pattern in the relations between species and the observed environment. CCA can deal simultaneously with many species and many environmental variables. The species are assumed to have a unimodal response to linear combinations of environmental variables (Ter Braak and Prentice 1988).

Red Oak Establishment Experiment

Three tree shelter treatments (Tubex® shelter, Tree Pro® shelter, or no shelter) and three weed control treatments (brush blankets, glyphosate spray, or no weed treatment) were combined in a factorial design and applied to newly planted bareroot seedlings of red oak (*Quercus rubra*) in the spring of 1994 at the Uxbridge pit of Lafarge Canada. Seedlings were planted in a randomized block design with 10 trees in each replicate and six replicates for each of the 9 treatments giving a total of 540 trees.

Tallgrass Prairie Experiment

Eight tallgrass prairie species from genotypes collected in southwestern Ontario were sown as seed or planted as plugs in 3m x 3m plots at the Henderson pit (Plympton Tp.) in June 1996. The eight species were *Andropogon gerardii* (Big Bluestem), *Sorghastrum nutans* (Indian grass), *Panicum virgatum* (Switch grass), *Desmodium canadense* (Showy Tick-trefoil), *Lespedeza capitata* (Round-headed Bush-clover), *Ratibida pinnata* (Tall Coneflower), *Rudbeckia hirta* (Black-eyed Susan), and *Asclepias tuberosa* (Butterfly Weed). Five plugs of each species were planted in each of the plug plots for a total of 40 plugs per plot. The three grass species were sown at a rate of 1600 seeds per plot and the forbs were sown at a rate of 960 seeds per plot for a total of 9,600 prairie seeds per sown plot. Both plug and seed plots were sown with a cover crop of either *Lolium perenne* (perennial rye), *Avena sativa* (cultivated oats) or received no cover crop. Cover crops were sown at a rate of 30 kg/ha. There were 5 replicate plots for each planting method/cover crop treatment combination for a total of 30 plots. A randomized block design was used to assign treatments to plots.

Results

The vegetation surveys of abandoned pits and quarries are turning up a wide variety of community types. Developing marsh, fen, swamp, prairie and alvar ecosystems have all been found on old extraction sites. Some examples of these are described below.

Kerncliff Quarry (City of Burlington)

Located right at the edge of the Niagara Escarpment where it was excavated into the original cliff face, this quarry supports a surprisingly large number of both native and non-native species for such a small site (3 ha approx.). The talus and boulder piles along the three quarry faces now support 34 tree and shrub species. Ground water seepage from the base of the north quarry wall accumulates in several large marly ponds near the north and east walls as the floor is higher towards the centre of the quarry. A marsh community dominated by both *Typha angustifolia* (Narrow-leaved Cattail) and *T. latifolia* (Broad-leaved Cattail) as well as several *Scirpus* (Bulrush) species has developed here. To the west is an associated wet meadow dominated by

Equisetum variegatum (variegated horsetail) and various *Carex* (sedge) species. Both Sora and Virginia Rails have bred here successfully indicating the relatively high quality of this small marsh.

Fletcher Creek Quarry (Puslinch Tp.)

In the1930's the Puslinch Quarry Co. excavated another 17 feet out of the north end of the older Maloney quarry. Constant seepage from this deep water area now flows across the floor of the older quarry which slopes to the south. An old narrow outlet channel at the south end was blasted through the rock. A rich fen is developing on the accumulating marl deposits in this seepage zone. Fen indicator species here include *Rhynchospora capillacea* (beak-rush), *Muhlenbergia glomerata* (Marsh Wild-timothy), *Spiranthes romanzoffiana* (Hooded Ladies-tresses) and *Liparis loeselii* (fen twayblade). A snake hibernaculum among the boulders and broken limestone pavement is used by eastern garter snake, northern ribbon snake, northern water snake and the eastern milk snake.

Wildwood Pit Complex (Zorra Tp.)

These pits were opened to provide aggregate for the construction of the Wildwood reservoir dam in the 1960's and later for development of the Wildwood conservation area. The last of these pits to be extracted now supports a fen community. As with the Fletcher Creek quarry, groundwater seepage plays an important role here although Ca and Mg concentrations are not as high due to the nature of the substrate. Groundwater discharge from the base of the sand and gravel ridges on the east side of the pit flows across the floor of the pit which is gently sloping from east to west. Toward the west side the seepage merges to form a small stream and then infiltrates into the sand and gravel layer at the toe of the west pit face. The fen community includes *Muhlenbergia glomerata*, *Equisetum variegatum*, six *Carex* species, *Liparis loeselii*, *Cypripedium reginae* (Showy Lady's Slipper) and the cotton grass *Eriophorum viridi-carinatum*. The pit is the only known location for this cotton grass in Oxford County (M.Oldham pers. comm.). The exposed sand and gravel ridges are used by turtles from the reservoir for egg laying and young snapping turtles take refuge in the deeper seepage zones.

Another, somewhat older pit in this complex is developing into a shrub swamp. While it has yet to be surveyed using the methods described above, the floor is dominated by *Cornus* (dogwood) and *Salix* (willow) species. As in natural swamps, the annual fluctuations in the hydrology at this site are extreme with 1.5 m of surface water being present in the spring while only a few small pools remain at the surface by the end of June. Wood frogs use this site for breeding in early spring.

Colwell Pit (Vespra Tp.)

Portions of this ballast pit used by CN Rail were being worked in the early 1970's but older parts were extracted in the mid 1940's. Much of the droughty sandy floor is dominated by the tallgrass prairie species *Schizachyrium scoparium* (Little Bluestem). Other prairie species that have colonized this site include *Andropogon gerardii*, *Elymus canadensis* (Canada Wild-rye), *Monarda fistulosa* (Wild Bergamot) and *Asclepias tuberosa*. The finding of a small patch of *Bouteloua curtipendula* (Side-oats Grama) at this site represents a new record for Simcoe Co. (W.Bakowsky pers. comm.). Given the rarity of this native grassland in Ontario today, it is interesting to speculate on the source of these naturally colonizing plants. One possibility is that the seeds came in on rail cars or that the plants spread slowly along the railway right-of-ways. Older rail lines often harbour prairie relics (Morgan et. al 1995). Another source could be the remnant native prairie which is still present on the old glacial lake shoreline at Fort Willow, 5.5 km away (W. Bakowsky pers. comm.). Regardless of source this large, open site with a rapidly draining, low nutrient substrate appears suited to these species. Ontario Hydro workers have indicated that garbage was often dumped at this site in the past and later set on fire by local youths. Certainly there is a strong connection between the maintenance of tallgrass prairie and periodic burning (Morgan et al 1995).

Old Point Anne Quarry (Thurlow Tp.)

Point Anne has a long history of quarrying and cement production going back to the turn of the century. Species from the surrounding natural alvar community have moved back onto the floor and the long low mounds of broken stone that are found in this very old quarry. Alvar species colonizing this site include *Juniperus virginiana* (red cedar), *Quercus macrocarpa* (Bur Oak), *Rhus aromatica* (Fragrant Sumac), *Penstemon hirsutus* (Hairy Beard-tongue), *Ranunculus fascicularis* (early buttercup), and *Bouteloua curtipendula*. As well, there are extensive thick crytogammic crusts on the floor of this quarry which are typically found on the exposed rock of natural alvars in Ontario (Reid 1996). These crusts may have an important role in nitrogen fixation, water retention and ultimately seedling germination and establishment (Casper et al. 1998). The hydrologic regime at this quarry is similar in many ways to the shrub swamp pit at Wildwood. Spring water levels are almost a metre deep in many areas of the floor with only the rocky mounds and talus remaining above water. By July the floor is dry and the very shallow soils are baked in the heat. This annual cycle of flooding followed by extreme drought may be critical in the maintenance of some alvar communities (Reid 1996; Catling and Brownell 1995).

A summary of the sites discussed above, the total numbers of native and non-native vascular plant species found in the quadrats, and the Floristic Quality Indices are shown in Table 1.

Site and Location	**Age Since Abandonment (approx.)**	**Major Ecosystem Type Developing**	**# Native Species**	**# Non-native Species**	**Floristic Quality Index ***
Wildwood Pit Zorra Tp.	25 years	Fen	80	39	25.48
Colwell Pit Vespra Tp.	25 years + portions back to 50 years	Prairie	55	18	28.56
Kerncliff Quarry Burlington	40 years	Talus Forest, Marsh and Wet Meadow	96	61	25.54
Fletcher Creek Quarry Puslinch Tp.	60 years + older portions	Fen and Alvar	73	21	31.15
Point Anne Quarry ThurlowTp.	65 years	Alvar	93	22	37.77
Deliberately Rehabilitated Sites (Age is years since rehabilitation done)					
Tp. of Uxbridge pit Uxbridge Tp.	2 years	Forb Meadow	17	25	5.38
Glen Major Pit Uxbridge Tp.	10 years	Forb Meadow	36	39	11.52

Table 1 **Site History, Location and Results of Floristic Quality Assessment based on Presence Absence Data from Vegetation Sampling Transects.**
*** Floristic Quality Index calculated to include non-native species**

Also included in Table 1 for comparison purposes are two younger, deliberately rehabilitated pits surveyed in the same manner as part of a study on naturalizing pits on the Oak Ridges Moraine (Dance & Browning 1998). The number of non-native vascular plant species exceeded the number of native species in the younger, deliberately rehabilitated pit sites (Table 1). Abandoned sites in the 25 to 50 year age range had approximately twice the number of native species compared to non-native species. The greatest overall species total (157 species) occurred in the quadrats at the 40 year old Kerncliff quarry. The two oldest quarries had fewer overall species but native species outnumbered non-natives by almost 4 to 1. The Floristic Quality Index (FQI) is very low in the youngest, deliberately rehabilitated site but doubles approximately every 10 years until about 25 years of age. After that age the FQI continues to increase but at a slower rate.

Multivariate analysis of the plant data and corresponding abiotic data collected from the quadrats is still on-going. However, in most cases to date the site hydrology is proving to be the main factor influencing the development of vegetation communities on abandoned extraction sites. This is illustrated in a CCA ordination diagram for data from the Fletcher Creek quarry shown in Figure 1. In the analysis two axes are chosen which account for the greatest amount of variation in total species composition between quadrats. The aim is to locate quadrats (or sites) that are similar in species composition close together on the axes and have quadrats that are dissimilar farther apart. Species are represented by diamonds corresponding to their approximate optima between the axes. Environmental variables are represented by arrows indicating their direction and rate of change. In this case quadrats with surface water ≥ 10cm deep were removed from the analysis as they were very different in plant composition from all other quadrats. Even with that adjustment, the x-axis which

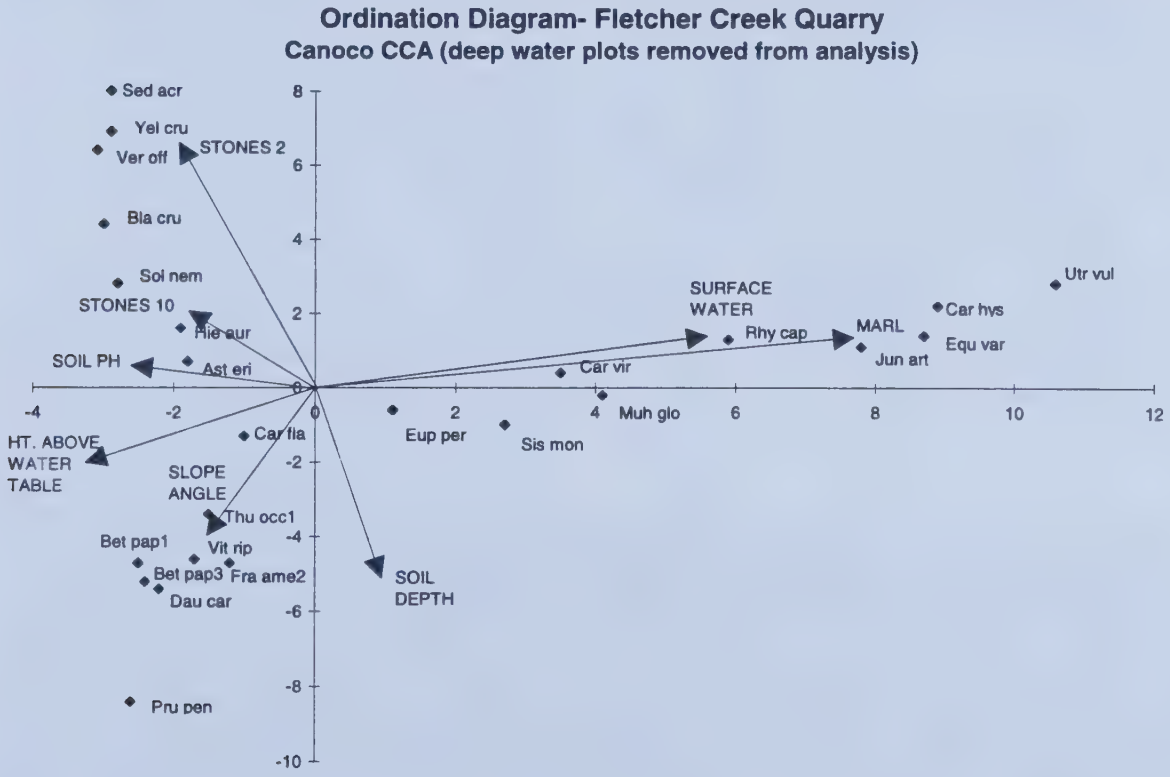


Figure 1 **Ordination Diagram for the Fletcher Creek Quarry. Axes 1 and 2 from a Canoco CCA Analysis with some Species Optima and major Physical Variables shown. (Quadrats with ≥10cm surface water depth were removed prior to analysis).**

explains the greatest amount of variation in the data is strongly related to the presence of surface water, marl (the calcium carbonate deposits which precipitate out of surface waters) and the height above the water table. All these arrows are relatively long and closely parallel the x-axis (Figure 1). Soil pH is also associated with this first axis. The y axis which explains the next biggest chunk of variation in plant composition between quadrats is related to soil depth and stoniness. Slope angle was also related to this second axis as vegetation on the sides of mounds and the main talus generally had deeper substrate to root in than plants on the gently sloping quarry floor.

Red Oak Establishment Experiment

The influence of tree shelter and weed control treatments on red oak seedling survival is shown in Figure 2. Seedling survival after 4 years ranged from 93% for those in Tubex shelters used in combination with brush blankets, to 27% for open grown red oak with no weed control. A two-way ANOVA on the arcsine transformed percent survival data indicated that both shelter treatment ($F=37.91$; $p \leq 0.0001$) and weed control treatment ($F=11.98$; $p \leq 0.0001$) had a significant effect on red oak survival. Both tree shelter types significantly improved seedling survival compared with open grown seedlings and a Tukey's studentized range test showed no difference between Tubex and Tree Pro. Similarly, using either brush blankets or glyphosate as a weed control significantly improved survival and there were no significant differences between these two weed control methods although the brush blankets had a mean survival rate that was 10% higher than the glyphosate treatment.

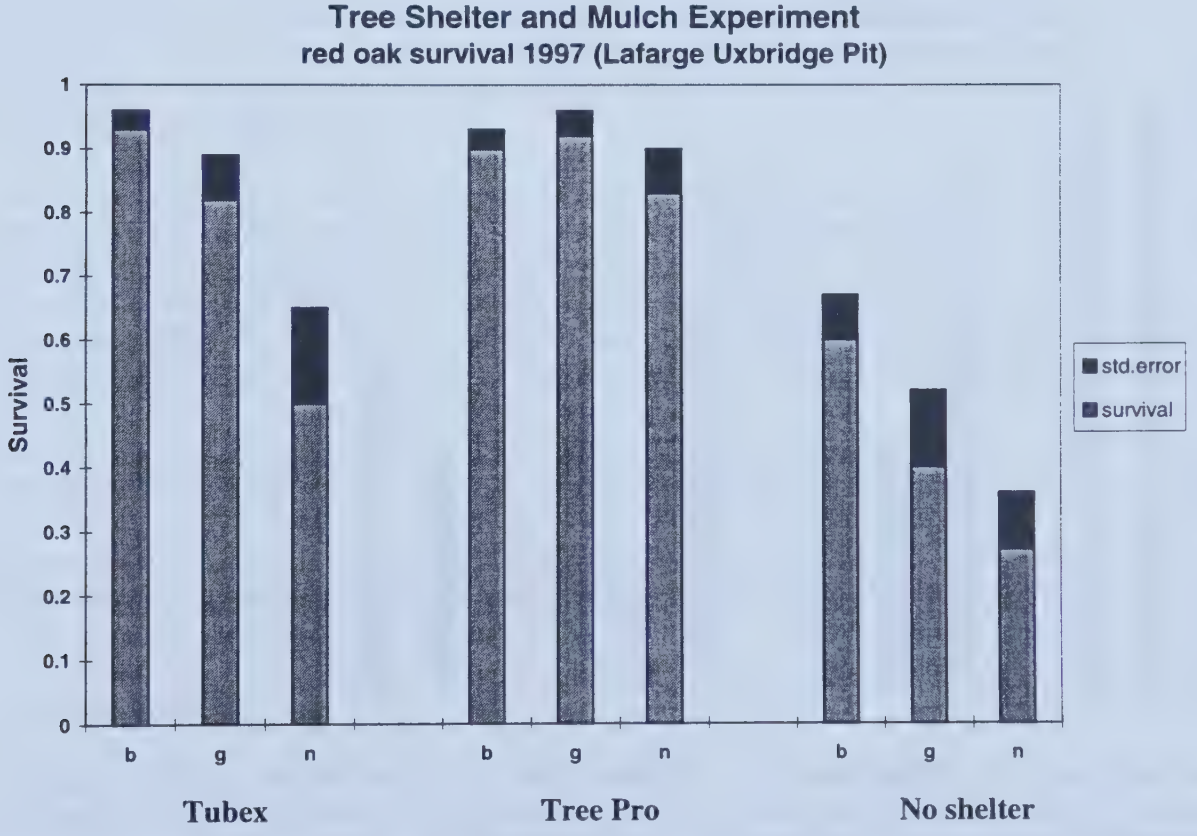


Figure 2 **The Influence of three Tree Shelter Treatments (Tubex, Tree Pro or No Shelter) and Three Mulch Treatments (Brush Blanket, Glyphosate, or None) on Survival of Red Oak Seedlings after 4 Growing Seasons in a Gravel Pit.**

b=brush blanket g=glyphosate n=no mulch treatment

Similar results were obtained for total seedling height and height increment but not for diameter increment. Many of the red oak have now grown out of the tops of the shelters and it will be interesting to see if the rapid height growth continues or slows.

Tallgrass Prairie Experiment

The perennial rye cover crop had a significant impact ($F=14.05; p \leq 0.0007$) on total weed cover in the prairie plots. Mean percent total weed cover during the second growing season was 20.4% in the no cover plots, 15.6% in the oat cover plots but only 3.6% in the perennial rye cover plots. In spite of this, cover crop treatment had no effect on plug survival. This points out the advantage of using plugs in prairie restoration projects. Large plants get a bigger head start on the weed species and are less likely to be out-competed. In the case of the seeded plots there was a significant interaction term between species sown and cover crop for seedling frequency ($F=2.76; p \leq 0.0018$). This indicates that the impact of cover crop varied depending on the species sown. The impact of cover crop type on four of the sown prairie species is shown in Figure 3. These species had different responses to cover crop. There was no impact of cover crop on seedling frequency for *Andropogon gerardii* but an increase in seedling frequency for *Asclepias tuberosa* and especially *Desmodium canadense* when sown with a perennial rye cover. The opposite response was seen in seedlings of *Rudbeckia hirta* which had the highest frequency in the no cover plots.

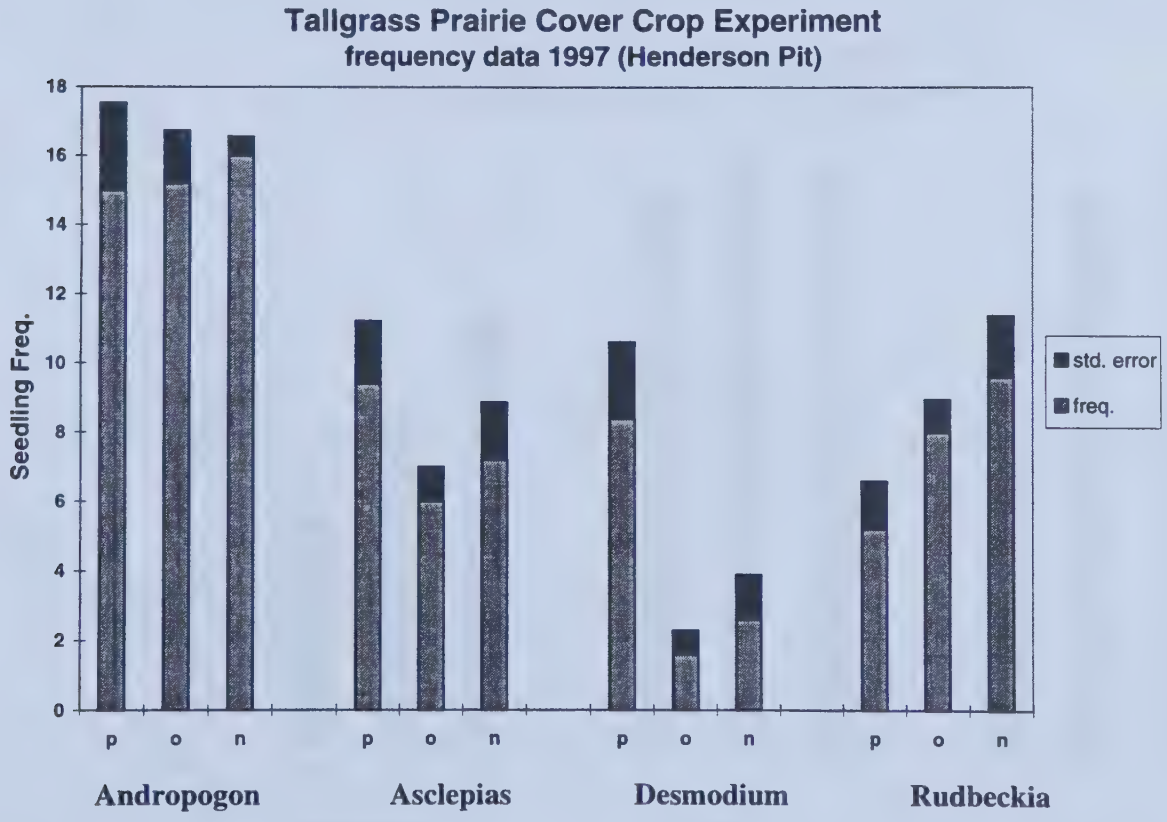


Figure 3 **The Influence of three Cover Crop Treatments (Perennial Rye, Oats or None) on the Seedling Frequency of four Sown Prairie Species during the 2nd Growing Season in a Gravel Pit.**
p=perennial rye o=oats n=no cover crop

Discussion

These results demonstrate that the potential is there for extraction sites to become good wildlife habitat and to support unusual and even rare native Ontario biotic communities. There is an important role for natural regeneration in the rehabilitation site plans of current and future licensed sites. It is critical to create the right physical conditions. The sites described above were abandoned ones that had no deliberate plantings done. However, they were left in such a way that the environment was suitable for certain groups of native species to colonize successfully.

One of the key elements influencing the successional patterns is the site hydrology and the related variables of topography and hydrogeology. These results points to some relatively simple structural work that can be done to direct naturalization. Groundwater seepage areas should be identified. Slope the pit or quarry floor towards these for marsh development. Sloping the floor gently away from these seepage areas should create the right hydrology for fen development. Elevation changes of only 1 or 2 meters in total across a site should be sufficient for this.

There is some indication from the results that quite long time periods, in the order of 25 years, are required for native plant communities to begin to dominate on former extraction sites, although this requires further work to confirm. It is important to start progressive rehabilitation early and to develop techniques for speeding the naturalization process. It appears to take 20 to 30 years for significant colonization by tree and shrub species in gravel pits on the Oak Ridges Moraine without active management (Dance and Browning 1998). Use of tree shelters, especially in combination with weed control, may be an answer for the rapid establishment of a native hardwood cover. The work by Ursic et al. (1997) on quarry faces points to the building of a suitable talus and the planting of white cedar (*Thuja occidentalis*) in this talus as a means for speeding development of a native cliff community on quarry walls.

The importance of maintaining corridors to surrounding natural areas for facilitating native plant colonization is demonstrated in the cases of the Colwell pit and the Point Anne quarry. Creating the right physical structure on site may not be enough without these linkages. Tallgrass prairie is such a rare ecosystem in Ontario now that in most locations there will be no prairie seed in the seed rain falling on a site. Plugs of prairie plants grown from local genotypes can be used effectively on pits sites. The importance of weed control and cover crops for direct seeding of these species has been shown. More work is needed on the relative merits of plugs vs. seed.

The Floristic Quality Assessment system for Southern Ontario provides a useful tool for comparing different sites and different rehabilitation strategies, and for tracking the progress of individual sites through time.

Next steps in this research will include developing and linking site level predictive models for naturalization to landscape level models of changing land use patterns to guide future planning and resource management.

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The Revegetation of Drastically Disturbed Lands

Charles Mrena

Natural Resources Institute, University of Manitoba

Abstract

During the development of natural resources such as forests and minerals, and in the construction of infrastructure and mega-projects, areas of land are disturbed and in many cases remain so for extended periods of time. For the purpose of this project, land is considered to be drastically disturbed if the native vegetation and animal communities have been removed and the topsoil is lost or altered, exposing a biologically barren subsoil surface condition. There are two basic approaches that can be taken in revegetating drastically disturbed sites devoid of topsoil or organic matter, they are: (1) Allow natural succession to take place; or (2) Give succession a "kickstart".

The purpose of this study was to identify and evaluate revegetation strategies and techniques which may serve to "kickstart" succession on drastically disturbed lands within the Manitoba Model Forest (MMF) region. The objectives of this study were: (1) To identify and review the revegetation strategies and techniques currently being used by various agencies; (2) To assess the identified revegetation strategies and techniques for use in Manitoba; (3) To evaluate the chosen revegetation strategies and techniques through field trials; (4) To make recommendations for the revegetation of drastically disturbed lands based upon the review of strategies and techniques, and the results of field studies with the principles of sustainable development in mind.

Field trials were used to assess the potential of hydroseeding and mulching around established trees and shrubs in the revegetation of drastically disturbed lands within Manitoba and the MMF. Materials tested included currently available hydroseeding products, including a bonded fiber matrix and a wood fiber product with tackifiers. These exhibited excellent adhesion on a variety of slope conditions as well as supporting germination rates of 50-80%. In addition, a paper mill sludge was evaluated for its potential as a component of a hydroseeding slurry and as a protective mulch (both as a dry mulch and a "hydromulch") for established trees and shrubs (Jackpine, *Pinus banksiana*; White spruce, *Picea glauca*; Buffaloberry (soap berry), *Schepherdia argentia*; Dogwood, *Cornus stolonifera*; Acute willow, *Salix acutifolia*; Wild rose, *Rosa sp.*; Hawthorn, *Crataegus arnoldiana*).

The paper sludge was easily applied as a slurry, exhibited excellent erosion control properties and supported germination rates of 60-80%. Results showed that the protective mulches had almost no effect on over-wintering success of the plants, with survival rates ranging from 94-100% in all treatments (with only one species, buffalo berry, at 88%). Regarding plant quality as related to the effects of the treatments, the plants receiving the 'hydromulch' treatment exhibited the best quality ratings. Five of the seven species benefited from the dry mulch treatment versus the control treatment, with only hawthorn and Jackpine not showing any derived benefits. Recommendations include: (1) utilizing commercially available hydroseeding products as a technique for revegetating drastically disturbed sites in Manitoba; (2) further research into the use of the paper mill sludge is a hydroseeding component; (3) utilizing the paper sludge, both as a dry mulch and 'hydromulch' to provide protection for established trees and shrubs, and (4) further research into the use of the dry mulch to provide impetus for succession based upon its apparent ability to support the establishment of pioneer and ruderal species in the trials.

Introduction

During the development of natural resources such as forests and minerals, and in the construction of infrastructure and mega projects, areas of land are disturbed and in many cases remain so for extended periods of time. For the purpose of this project, land is considered to be drastically disturbed if the native vegetation and animal communities have been removed and the topsoil is lost or altered, exposing a biologically barren subsoil surface condition.

Revegetating Drastically Disturbed Lands

There are two basic approaches that can be taken when revegetating drastically disturbed sites devoid of topsoil or organic matter, they are:

1. Allow natural succession to take place. This entails the establishment of pioneer plant species on sites lacking any topsoil or organic matter. With time, stabilization of the soil by root systems reduces erosion, the development of a thin organic layer takes place a result of decomposition, which in turn will encourage establishment by other plants and eventually leads to a climax community; or
2. Give succession a "kickstart". Provide inputs, to what ever degree is necessary based on the desired goal for the disturbed site. Inputs can be as simple as drill seeding with grasses and legumes, providing fertilizers to aid establishment, etc.. Once a vegetative cover has been established, further inputs can then be made to encourage desired species to grow, such as pulp wood tree species, or nature can be left alone to take its course.

The Manitoba Model Forest Program

This project originated with the Manitoba Model Forest Program (MMF), who identified drastically disturbed lands as sites which require revegetation in order to provide for the sustainable use of forest resources. The objectives of the MMF Program are:

1. To accelerate the implementation of sustainable development in the practice of forestry;
2. To apply new and innovative approaches, procedures, techniques and concepts in the management of forests; and
3. To test and demonstrate the best forestry practices utilizing the most advanced technology and forest practices available.

(Canadian Forestry Service 1996)

Purpose and Objectives

The purpose of this study is to identify and evaluate revegetation strategies and techniques which may serve to "kickstart" succession on drastically disturbed lands. The objectives of this study are: (1) To identify and review the revegetation strategies and techniques currently being used by various agencies; (2) To assess the identified revegetation strategies and techniques for use in Manitoba; (3) To evaluate the chosen revegetation strategies and techniques through field trials; and (4) To make recommendations for the revegetation of drastically disturbed lands based upon the review of strategies and techniques, and the results of field studies.

Methodology

The following approaches were selected for evaluation by field trials:

- Hydroseeding
- Protective mulches for tree and shrub plantings in the form of a paper mill sludge

Pine Falls Paper Company Paper Mill Sludge

In June 1996, the Pine Falls Paper Company (PFPC) located within the MMF, began to produce a biosolid waste material (also known as paper sludge) as a result of the operation of its new waste treatment plant. This material represents a sustainable source of organic mulch. Although literature showed that this type of material had been utilized as a soil amendment (Thacker and Macyk 1995), its use as a protective mulch was limited and as a component of a hydroseeding slurry was not documented. It was therefore decided that the material would be evaluated as a protective mulch for established plants rather than as a soil amendment and as a possible component of a hydroseeding slurry.

Site Selection

One of the most readily available drastically disturbed lands within Manitoba comes in the form sand and gravel pits. They are characterized by extreme slopes, are usually devoid of any topsoil materials and are typically not revegetated. In consultations with Mr. Stan Kaczanowski, Regional Forester, Manitoba Department of Natural Resources, and Mr. Brian Bailey, Rehabilitation Specialist, Manitoba Department of Energy and Mines, appropriate sand and gravel pits were selected as locations for field trials.

Field Trials

The field trail component of the practicum was divided into two parts:

- Part One: Evaluation of the Hydroseeding technique and products; and
- Part Two: Evaluation of a Paper Mill Sludge as a protective mulch for established plant material.

Part One: Evaluation of the Hydroseeding technique and products

Hydroseeding Treatments

The hydroseeding treatments were:

- Mat, Inc. Soil Guard™, tackifier , red clover and annual rye grass
- Mat, Inc. Soil Guard™, tackifier and Pickseed Canada Inc.'s "Custom Forage Mixture" (8% common cinquefoil, 8% white clover, 10% perennial ryegrass, 20% common bromegrass, 20% creeping red fescue, 10% rangeland alfalfa, 24% fylking kentucky bluegrass), pre-soaked.
- Canfor's Ecoaegis™ and Pickseed Canada Inc.'s "Custom Forage Mixture", pre-soaked.
- Canfor's Ecofiber™ and Pickseed Canada Inc.'s "Custom Forage Mixture", pre-soaked.
- Mat Inc. Soil Guard™, red clover and annual rye grass.
- PFPC based hydro mulch, red clover and annual rye grass.
- PFPC based hydro mulch with Jackpine (*Pinus banksiana*) seed.

Performance evaluation of the hydroseeding products included field notes and photographs taken during inspections of the treatments. The following set of 'subjective' criteria were also used to assess performance:

- The ability of the product to remain intact and viable;

- The approximate degree of "weed" (or undesirable plants) control provided; and
- The estimated rate of germination (when applicable).

Part Two: Evaluation of a Paper Mill Sludge as a protective mulch for established plant material.

Plant Selection

The plants selected were native to the boreal forest of the MMF and/or an economically important species. They included: Acute willow, *Salix acutifolia*; Buffaloberry (soapberry), *Schepherdia argentia*; Dogwood, *Cornus stolonifera*; Hawthorn, *Crataegus arnoldiana;* Jackpine*, *Pinus banksiana*; White spruce*, *Picea glauca*; Wild rose, *Rosa sp.*. The acute willow came in the form of dormant cuttings (approximately ten centimeters long) with the remaining plant material coming as bare root stock from PFRA. The nursery stock (*) was two years old, having been originally grown in 'cells' for two seasons, then kept in cold storage until needed. The PFRA material was one year old.

Tree and Shrub Field Trial Plot Design

Trials plots consisted of the three treatments each with twenty eight (28) 1.0 meter x 1.8 meter plots per treatment, for a total of eighty four (84) plots. Each plot was cleared of any existing vegetation then five plants of each species was planted within each plot, as shown in Figure 1, Plot Layouts. Four replications of each plant species took place within each treatment. Twenty (20) plants were installed per treatment, for a total of sixty (60) plants per species. The total number of plants installed per treatment was n = 140, for a total number of plants installed being n = 420.

Protective Mulch Treatment

The Protective Mulch treatments:

- Treatment 1: (Control) Established plant material with no protective mulch.
- Treatment 2: (Dry mulch) Established plant material with dry PFPC paper sludge as a protective mulch.
- Treatment 3: (Hydromulch) Established plant material with PFPC sludge used as the base for a protective layer of 'hydromulch'.

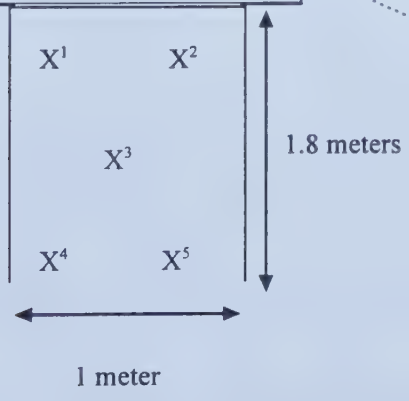
Treatment Application

Once the plants were well established the dry mulch and 'hydromulch' treatments were applied (July 18th and 19th, 1996 respectively). Watering of the plants was discontinued and weeding of the plots was done only once (mid August, 1996). The dry mulch was applied to the surface and around the established plants using wheelbarrows and spreading it with rakes to a thickness of eight to ten centimeters. The 'hydromulch' was applied with a hydroseeding machine, operated by Mr. Mark Myrowich of Mid-Canada Hydroseeding Ltd..

Figure 1: Plot Layouts

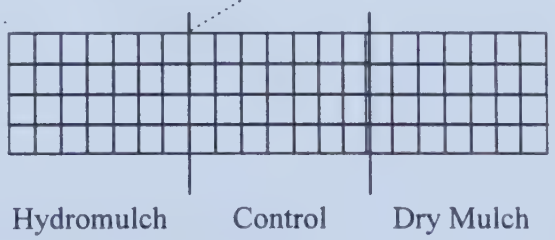
Hawthorn	Dogwood	White Spruce	Acute Willow	Buffalo-berry	Rose	Jackpine
Acute Willow	White Spruce	Buffalo-berry	Dogwood	Hawthorn	Jackpine	Rose
Jackpine	Buffalo-berry	Rose	Acute Willow	Dogwood	White Spruce	Hawthorn
Rose	Buffalo-berry	Dogwood	White Spruce	Hawthorn	Acute Willow	Jackpine

Orientation of Plants within Individual Plots



'X[1]' Indicates location of plant within the plot. Superscript indicates plant number.

Layout of Treatments in Field Trials



Evaluating Performance

Plant performance was evaluated by recording mortality rates, specifically overwintering survival rates, and by assessing overall plant quality as per Kennedy (1984) and Larson *et al.* (1993). The criteria used to evaluate individual plant performance appear in Table 1, Plant Quality Ranking and Assessment Criteria. The assessment of plant quality was done in June 1997, approximately one year after the installation of the plant materials when the deciduous plants had fully developed their leaves and conifers showed new growth as indicated by the development of candles.

Rank	Description	Criteria
4	Very Good Health	• All leaves exhibit good colour and rigor. • Branches full and normally developed. • New growth exhibited. • Superior specimen
3	Good Health	• No dead leaves on entire stem. • Branches full and developed. • New growth evident.
2	Moderate Health	• 25 % or less dead leaves on entire stem.
1	Poor Health	• 75% or greater dead leaves on entire stem

Table 1: Plant Quality Ranking and Assessment Criteria

(Adapted from Kennedy 1984, Larson *et al.* 1993)

Statistical Analysis

Statistical analysis included ANOVA, F-tests and t-tests to determine whether or not the differences in plant quality between treatments were significant.

Results and Discussion

Part One: Evaluation of the Hydroseeding technique and products

- Mat, Inc. Soil Guard™ , Canfor's Ecoaegis™ , and Canfor's Ecofiber™

The ability of the product to remain intact and viable.

All three treatments Mat, Inc. Soil Guard™ , Canfor's Ecoaegis™ , and Canfor's Ecofiber™ performed equally well. A site visit, in June 1997, found that all the materials had begun to break down. However, they remained intact and viable and erosion of the bank material was not observed.

Approximate degree of weed control provided.

No observable weed growth was observed to have taken place in either growing season (1996 and 1997) in any of the treatments.

The estimated germination rate.

On those sites where germination took place, the estimated rate ranged from 50% to 80%, with the latter rates observed in the bottom of rills.

- PFPC based hydro mulch.

The ability of the product to remain intact and viable.

It was observed that as the PFPC material dried it shrank into 'patties', but did remain in place. These patties were approximately ten to twenty centimeters across in size with gaps in between of one to three centimeters. The material adhered well to the surface and appeared to mold itself to the shape of the surface. There was no discernible erosion of the treatment area observed in the first year (1996) and a very limited amount in the second year (1997). The product remained intact and viable.

Approximate degree of weed control provided.

Estimated weed growth in the first growing year (1996) was less than 10% and approximately 10 to 20% in the second year (1997). It was only within the gaps between the patties that weed growth took place.

The estimated germination rate.

A germination rate of 60-80% was observed. The higher rate (80%) being observed in the rills and the lower rate (60%) being observed on the crests and flatter areas of the treatment site.

- Jackpine Seed in PFPC based hydro mulch.

The ability of the product to remain intact and viable.

Observations for this treatment are similar to those of the previous application.

Approximate degree of weed control provided.

The same observations were made as in the previous treatment.

The estimated germination rate.

No germination of the Jackpine seed was observed to take place.

Part Two: Evaluation of a Paper Mill Sludge as a protective mulch for established plant material.

Mortality

The over-wintering success rate was the first criteria used to evaluate the effects of the treatments on plant performance. The results appear in Table 2, Over-wintering Success Rates.

Species	Viable plants (fall 1996)			Viable Plants (spring 1997)			Survival Rate (%)		
	Hydro	Control	Dry	Hydro	Control	Dry	Hydro	Control	Dry
Hawthorn *Crataegus arnoldiana*	20	17	20	19	17	19	95	100	95
Dogwood *Cornus stolonifera*	17	20	20	16	20	20	94	100	100
White Spruce *Picea glauca*	20	20	20	20	20	20	100	100	100
Acute Willow *Salix acutifolia*	15	13	4	15	13	4	100	100	100
Buffaloberry *Schepherdia argentia*	18	17	19	18	15	19	100	88	100
Rose *Rosa sp.*	19	20	20	19	20	20	100	100	100
Jackpine *Pinus banksiana*	20	16	14	20	16	14	100	100	100

Table 2: Over-wintering Success Rates

For all species and in all treatments the survive rates ranged from 94% to 100%, except for the control treatment of the buffaloberry in which only 88% of the plants in the control survived. Total survival rates for all treatments, including the control, were excellent. The anomaly in the results was in the number of acute willow that were alive in the fall of 1996. The willow did not establish well at the outset of the trials, with only four specimens of the dry mulch treatment remaining viable entering the winter. This fact is reiterated in the results of the plant quality evaluation that follows. It should be noted however, that from the time the treatments were applied, no other plants were lost.

Evaluating Plant Quality

Table 3, Ranking of Treatments, provides a comparison of the performance of the quality of the plants between species as related to treatments. The average plant quality values recorded were arranged in descending order. The plant quality rankings were found to be statistically significant.

Plant	Ranking of Treatments (from highest assessed quality to lowest)		
Hawthorn	Hydromulch (3.35)	Control (2.27)	Dry mulch (2.18)
Dogwood	Hydromulch (3.87)	Dry mulch (3.20)	Control (2.08)
White Spruce	Hydromulch (3.35)	Dry mulch (2.60)	Control (1.90)
Acute Willow	Hydromulch (3.88)	Dry mulch (3.00)	Control (1.69)
Buffaloberry	Hydromulch (2.78)	Dry mulch (2.26)	Control (1.60)
Rose	Hydromulch (3.43)	Dry mulch (3.35)	Control (2.25)
Jackpine	Hydromulch (3.15)	Control (1.99)	Dry mulch (1.93)

Table 3: Ranking of Treatments (based upon overall plant performance).

Hydromulch

As can be seen from Table 3 the highest quality plants for all species were associated with the hydromulch treatment. The plant quality of the hydromulch treatment ranged from a low of 2.78 (Buffaloberry) to a high of 3.88 (Acute Willow). The most striking difference between the treatments was in size of the plants. Growth by the hydromulched plants was in some cases double that of their counterparts in the dry and control treatments and was exhibited by extensive branching and large bark green leaves in the deciduous species and by extensive leader growth and needle production in the coniferous species. The size differentiation of the plants of the hydromulch treatment versus the control ranged from approximately 20% as exhibited by the dogwood, to 200% by the rose. The remaining species in the hydromulch treatment were observed to be between 20% and 100% larger than those of the control. When comparing the plants of the hydromulch versus those of the dry mulch, the former ranged from having no discernible difference in size, (Jackpine), to being 100% larger (rose). There was also no chlorosis observed in the hydromulched plants.

Dry mulch

The quality of the plants in the dry mulch ranged from a low of 1.93 (Jackpine) to a high of 3.35 (Rose). Five of the species produced better quality plants in the dry mulch treatment versus the control, with Hawthorn and Jackpine being the exceptions. New growth was also observed by plants of the dry mulch treatment. The plants of the dry mulch treatments were characterized by excellent colour. Some chlorosis was observed, however this was limited to four or five individual plants and was not associated with any one species in particular.

Control

The plants in the control had plant quality values ranging from 1.60 (Buffaloberry) to 2.27 (Hawthorn). The plants were small in comparison to those in the other treatments, chlorotic and devoid of substantial vegetation.

Capacity as a Seed Bed

The dry mulch appeared to support the establishment of other plant species, with up to 100% ground coverage observed by the end of the 1997 growing season.

Conclusions and Recommendations

Hydroseeding

The results of this research indicate that hydroseeding is a viable and versatile technique for the revegetation of drastically disturbed lands. All of the products tested were able to form stable mats on a variety of soil surfaces and under a variety of conditions thus providing erosion control, weed suppression and for the establishment of desirable plant species. Even under extremely harsh conditions, such as slopes of 1:1 and areas of severe rilling, the vegetation became established with no further inputs being necessary.

The use of the Pine Falls Paper Company paper sludge as a component of a hydroseeding slurry also proved promising. Its level of performance in critical areas rivaled that of the commercially proven products. It was able to form a relatively stable mat on both flat and sloped conditions and remained intact for two growing seasons; adhered well to variety of surfaces thus resisting erosion; and, exhibited the ability to support exceptional germination rates of 60 - 80%. The lack of germination by the Jackpine seed could be attributed to a lack of stratification, although no germination was observed in the second year either (Kaczanowski pers comm 1997). The failure of the clover and annual rye grasses after they germinated is most likely due to desiccation as there was a lack of precipitation at a critical period of time in the establishment of these seeds. Even the commercially proven products only continued to support plant growth in the rills, where both product and much needed moisture accumulated. These results underscore the importance of timing the use of hydroseeding with periods and seasons of precipitation and low temperatures so that success rates can be higher. Pre-soaking the seeds prior to their use may have had a detrimental affect on germination rates. Pre-soaking would have stimulated the seeds to begin germinating, making them very susceptible to desiccation by the subsequent lack of moisture (there was no precipitation on the treatment areas for three weeks after the hydroseeding took place). In general, the hydroseeding products were able to form a stable mat that provided erosion control on slopes, reduced competition by weeds and resulted in high rates of germination when sufficient amounts of precipitation were available. Hydroseeding would therefore be an excellent approach for the revegetation of drastically disturbed sites. The use of the PFPC paper sludge as a component of a hydroseeding slurry also shows potential as it preformed well in the parameters used to evaluate hydroseeding

products. It was able to form a stable mat, provided good erosion control, acted as an effective weed barrier and began breaking down with time.

Protective Mulches

The over-wintering success assessment was inconclusive as there was almost no difference observed in mortality between those plants protected by mulches versus those in the control. The only species that showed that it may benefit from the mulches was the buffaloberry, which had a survival rate of 88% without mulching as compared to 100% with mulching. The reason for the extraordinary ability of the plants to overwinter may be related to the following factors. Firstly, the plants were very well established in 1996, having been planted in June and being regularly watered until the application of the treatments some six weeks later. Secondly, the 1996 - 1997 winter was characterized by some of the highest accumulations of snow in the last century (Anderson pers comm 1998). The exceptional amount of snow fall would provide an excellent insulating layer that would have protected the plants from the extremely cold temperatures that also characterized the 1996 - 1997 winter season. In addition, the thicker snow layer would have provided protection from browsers. The greater accumulation of snow would have been followed by a higher than normal spring runoff in 1997, thus providing the plants with an excellent start in the spring. These climatic factors, coupled with the fact that the plants were well established the previous growing season, may have contributed to the high survival rates observed.

In contrast, the results of the plant quality assessment suggest that plants were able to derive benefit from the use of the paper sludge as a protective mulch, both as a dry mulch and as a "hydromulch". All seven species under the hydromulch treatment were characterized by large green leaves, a lack of chlorosis and the presence of new and vigorous growth. Both the tree and herbaceous species benefited. Literature reviewed lists the benefits of mulches as being moisture and nutrient retention and better plant quality as a result of reduced competition from weeds. Both mulch treatments appear to provide these benefits, with the hydromulch being particularly effective. It was able to form a durable and stable mat that adhered itself to the surface of the treatment sites on a variety of surfaces from sandy soils to gravel/sand soils. As a result there was little erosion of the surface covered by the hydromulch on slopes with gradients of up to 3:1 with no rilling of these areas being observed. The material remained viable and intact for two growing seasons and therefore resisted erosion by both wind and rain. The hydromulch also provide excellent weed control with the establishment of undesired plant species never exceeding 20% of the plot area. As a result, the competition for limited nutrients and moisture was eliminated, allowing the desired plants to flourish.

The dry mulch treatment produced plants somewhat poorer in quality than those of the hydromulch, however they were still superior to those of the control. This is most likely attributable to the lack of ability of the dry mulch to suppress undesired plants to establish themselves. Infestation rates approached 100% by the end of the second growing season and the presence of these plants resulted in competition between the desired trees and shrubs and the undesired species for the limited nutrients and moisture on the sites. However, what is important is that ruderals were able to establish themselves quite easily on the dry mulch material. By providing the necessary conditions for the re-establishment of pioneer species the process of natural revegetation of the drastically disturbed site was greatly enhanced. The dry mulch was very susceptible to both wind and water erosion, and over the two growing seasons it accumulated at the bottom of rills and was transported up to two feet downhill of the perimeter of the plots. The material lacked the ability to form a resilient and erosion resistant mat. The use of this material may therefore be limited to areas with little or no slope where erosion is not a concern.

As has been noted, all seven plant species performed best in the hydromulch treatments. Only the Jackpine and Hawthorn failed to draw any apparent benefit from the dry mulch. Chlorosis was found to be exhibited by all plants in the control, while none was observed among the plants in the two mulch treatments. The most resilient plant was the rose. It was observed as a pioneer species at the site and is naturally establishing itself along the periphery of the borrow pit. The surprise of the group was the acute willow. If it became established, it flourished under the mulch treatments, particularly the hydromulch. However, the need for protection could limit its usefulness. The performance of buffaloberry was surprisingly disappointing in that although it is capable of fixing nitrogen, its performance was the poorest of all the plants in the control treatment and also received the lowest quality ranking in the hydromulch treatment. It usefulness in revegetation may therefore be limited. Although the hawthorn benefited from the hydromulch, it was also able to grow satisfactorily under the control conditions. This suggests that it could also be useful as a pioneer species where mulching was not available, and would thrive in circumstances where mulching was available. The dogwood benefited greatly from the mulches and would require such protection if it is to be used in similar conditions. The Jackpine responded very well to the hydromulch treatment and poorest to the dry mulch treatment. If planting of this species was required on sites with slopes, then the use of the hydromulch would be beneficial to the revegetative effort. On areas with little or no slope, this species would draw little benefit from the application of mulches. Conversely, the white spruce responded very well to both mulches and as such, any project to revegetate an area with this species could benefit from the use of a protective mulch.

In conclusion, the benefits of the hydromulch appear to be related to its ability to suppress the growth of undesired plants, thus reducing or eliminating competition for nutrients and moisture; in its capacity to control erosion, thus providing for a stable growing medium; and finally in its ability to retain moisture either by reducing movement of water across its surface and thereby allowing for its infiltration and/or by reducing its loss through evaporation. The dry mulch material supported the establishment of ruderals. It appears to possess the necessary qualities to provide for the re-establishment of pioneer species, thus the process of natural revegetation of the drastically disturbed site was greatly enhanced. Overall, the PFPC paper sludge exhibited the characteristics important to be an effective and protective mulch and as such should be strongly considered in revegetation approaches of drastically disturbed sites. It could prove to be of benefit on sites with even the slightest of slopes, such as ditches, rights of way, temporary logging and access roads, and borrow pits including sand and gravel pits. In situations where the goal is to revegetate with desired species, then the use of the hydromulch would be an appropriate technique.

The results of this project suggest that hydroseeding and protective mulches would be excellent techniques in efforts to "kickstart" the natural revegetation of drastically disturbed lands within Manitoba and the Manitoba Model Forest region.

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This practicum has been recognized for its contribution to the pursuit of sustainable development by receiving a nomination for a 1997 Province of Manitoba Sustainable Development Award of Excellence, in the category of research and development.

CALEDON CREEK AND CREDIT RIVER SUBWATERSHEDS – A CASE STUDY

Hazel Breton, P. Eng.

Credit Valley Conservation

ABSTRACT

The Caledon Creek and Credit River Subwatershed study is a three-phased assessment that details the environmental and water related issues. These subwatersheds have been undergoing increasing development pressures including extraction activities and related land uses of existing pits as well as expansion of licensed areas. Specifically, an analysis of the groundwater and surface water hydrology, riparian and aquatic and terrestrial habitat, water quality and stream morphology were undertaken. The goal of these analyses was to achieve a thorough understanding of how the ecosystem functions and how land use changes will impact upon it.

Background

Project History

In January 1992, Credit Valley Conservation (CVC) in concert with all member municipalities and the Ministries of Natural Resources (MNR) and Environment (MOE), completed a watershed management plan titled *Credit River Water Management Strategy* (CRWMS), Phases I and II. These studies evaluated the present and future state of the Credit River Watershed with respect to overall health. The results for the future scenario indicated that the ever-increasing pressures for development and resource use, the impacts to the watershed if not properly managed would be irreparable. The study recommended that the entire watershed be subdivided into 20 subwatersheds and that plans be prepared in order to properly manage the health of the watershed.

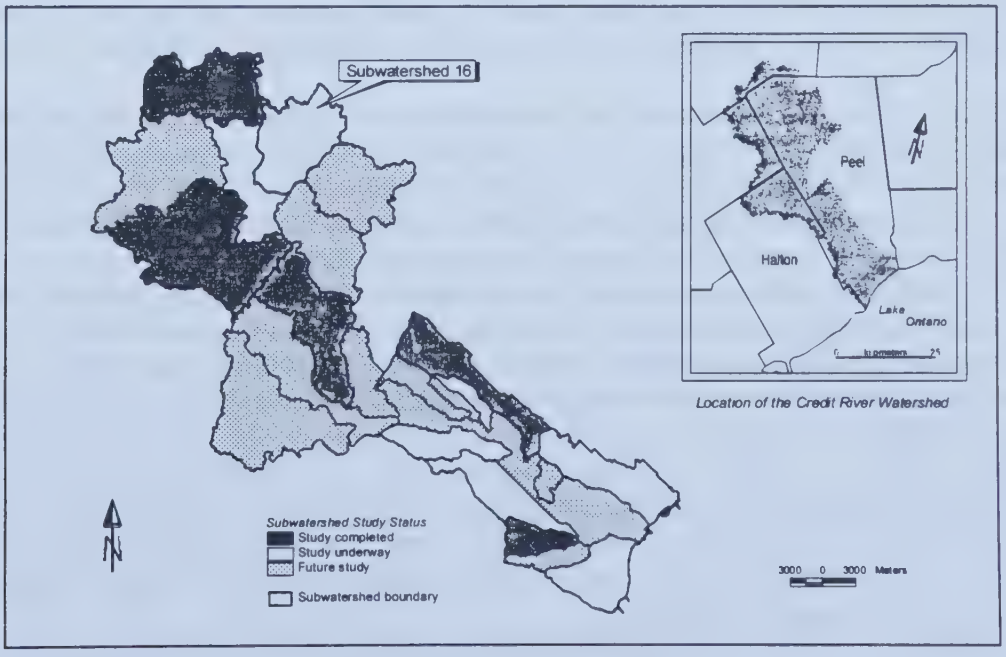


Figure 1 shows the location of the Credit River Watershed with respect to Lake Ontario and also shows the location of the subwatersheds under study within the Credit River Watershed.

The Caledon Creek and the Credit River Subwatersheds (Subwatersheds 16 and 18) have been undergoing increasing development pressures including extraction activities and related land uses of existing pits as well as expansion of licensed areas. This has caused a number of agencies including Region of Peel, Town of Caledon, Credit Valley Conservation (CVC) and the Niagara Escarpment Commission to express a significant concern over the lack of a comprehensive area-wide analysis of the cumulative impacts on the environment and the community, caused by land use changes. As a result, these agencies gave their support for initiating the subwatersheds study. CVC was requested to manage the study and the Region of Peel allocated the financial resources necessary to carry out the study.

Study Purpose

The study covers the environmental and water related issues within Caledon Creek (Subwatershed 16) and the Credit River (Subwatershed 18). Specifically, an analysis of the groundwater and surface water hydrology, riparian and aquatic and terrestrial habitat, water quality and stream morphology were undertaken. The goal of these analyses was to achieve a thorough understanding of how the ecosystem functions and how land use changes will impact upon it. The study is intended to be used as one component of a land use management strategy that may be developed by municipal partners in an effort to balance economic, social and environmental needs within the community.

Related Initiatives

Coordination with other ongoing initiatives has been essential in order to take advantage of collecting additional information and realizing cost savings to the study. Such initiatives include ongoing subwatershed studies (Subwatersheds 19 and 15); the Caledon Community Resources Study and the Town of Caledon Well head Protection Area Program.

Study Process

The study is managed on a daily basis by CVC. The overall direction is provided by a Technical Committee made of representatives from Region of Peel, Town of Caledon, Niagara Escarpment Commission, MOE, MNR, CVC and a representative from the local aggregate operators. Each representative in turn reports to senior management whom in turn report to Municipal Council, Commissions or Board of Directors.

The study has been divided into three phases and is to be carried out over a two-year timeframe. The following describes each phase:

- Phase I – This is the Characterization Phase and can be defined as the assessment that is carried out to establish the form, function and linkages of the various components of the natural environment. In order to characterize the subwatershed, an inventory of existing information was carried out in order to establish data gaps and refine the proposed field program to collect the important missing data. The field program was initiated early in the study process in order to take advantage of seasonal conditions. This phase was concluded with a report that summarizes the important water linkages between environmental components.
- Phase II – This is the Impact Assessment Phase and can be defined the assessment whereby the response of the subwatershed is determined by applying various stressors over time using predictive models. The objective of this phase is to determine subwatershed sensitivity to these stressors in order to determine the limits to change and the ability to apply various mitigative measures to avoid cumulative impacts.
- Phase III – This is the phase in which the Vision and Goals developed for the subwatershed are utilized to assist in selecting those mitigative measures that offset the impacts from future land use changes. An Implementation Plan is developed and responsibilities are assigned to ensure that the

recommendations of the study are followed. Implementation is usually overseen by an appointed committee the issues usually center around ensuring that recommendations are followed up on and land use planning policies, stewardship and education, retrofit and rehabilitation, monitoring and research and development.

The conclusion of the study does not signal an end to process but a beginning to managing our actions in an adaptive manner. As additional monitoring is carried out over time, initial assumptions and the predictive tools used can be checked and necessary modifications to management decisions can be made.

Subwatershed Characterization

Methodology

The approach taken for this phase was to divide the natural environment into components, study each in detail and then re-aggregate the system so that the findings could be integrated in a manner that allows the important water linkages to be defined.

Component Studies

Hydrogeology

The movement of groundwater in the area is primarily controlled by the geologic setting. Highly permeable sand and gravel materials located along and adjacent to the Credit River and the main branch of the Caledon Creek provide excellent areas for water to infiltrate into the ground and recharge the groundwater. Most recharge in this area become part of a larger more regional groundwater flow system. The till units in the northeastern part, and just south of subwatershed 16, provide important, but lesser opportunity for water to enter the ground, and provide water to the local aquifer system.

Groundwater flow radiates out from the groundwater high located in the till unit in the northeastern portion of Subwatershed 16. Groundwater originating from this area provides baseflow to Caledon Creek, the Credit River, the Humber River (outside of the Credit River watershed) and the Little Credit River (Subwatershed 13).

The Amabel formation, a permeable dolostone bedrock unit underlying much of the study area is the medium through which most of the groundwater in the subwatersheds travels through to adjacent areas. This is evident in the southern portion of Subwatershed 16 where the groundwater flows through the bedrock and into the sand and gravel along the buried Niagara Escarpment. Providing the source of headwaters for the Little Credit River.

The western portion of the Caledon Meltwater Channel has a large storage volume and is the conduit for much of the groundwater that flows through the regional system toward the Credit River. At its westerly boundary, the unit fans out. Groundwater flows this deltaic path into the Credit and results in significant discharge to the river downstream of the Caledon Creek confluence. Further groundwater contributions to this reach originate in the West Credit (Subwatershed 15). As much as 15% of the water recharging Subwatershed 15 discharges into Subwatershed 18. Other areas of less significance include the upstream reaches of Caledon Creek (local recharge only), and the upstream reach of the Credit River (moderate regional recharge contributions).

Hydrology

Specific characteristics found in Subwatersheds 16 and 18 impose a dominant influence on the flow response in these areas. The dominant characteristics identified here include: significant closed drainage systems, limited

municipal drainage, significant floodplain storage (Subwatershed 18 only), high percentage of forest cove, prevalence of high infiltration soils, and the presence of significant extraction activities.

The near absence of municipal drains combined with hummocky topography associated with the Singhampton Moraine and large wetland areas have resulted in large areas with either no surface drainage outlet or restricted outlets. These areas are referred to as closed drainage systems. Precipitation is retained in these areas, and either recharges the groundwater aquifers or evaporates. Closed drainage systems occur mostly in the Caledon Creek subwatershed, and account for about 30% of the area.

Channel floodplain storage is a dominant feature of Subwatershed 18, where the Credit River follows a broad glacial spillway. The broad floodplains and flat channel gradients associated with these spillways result in considerable floodplain storage, which greatly attenuates flood flows originating in the headwaters of the Credit River.

Subwatersheds 16 and 18 have significant forest cover. The high infiltrability associated with the soils under forest cover restricts the amount of precipitation appearing as runoff for entry into the surface drainage network. In addition, snowmelt in heavily forested areas melts much later than agricultural areas. The delayed snowmelt reduces the potential for flooding and provides additional opportunities for groundwater recharge.

The predominance of highly permeable soils in Subwatershed 18 and the lower portion of Subwatershed 16 results in high recharge rates to groundwater aquifers, and reduced surface water runoff to flow within the subwatershed. Field observations confirm that many reaches of the Caledon Creek have no permanent flow, drying up each spring and summer. Flow is likely to occur in many reaches only during the spring freshet, when frozen ground conditions contribute runoff for all soil types.

Stream Morphology

Characterization was completed at the basin scale and utilized background documentation, air photos, and field analyses. Channels within Subwatershed 16 are typically classified as 'C-type' with some tributaries exhibiting steeper and entrenched conditions, similar to a 'B-type' channel. The headwaters have been largely modified for agricultural use, thereby reducing its stability. The creek conveys very little flow and sediment which results in a narrow channel which is highly influenced by riparian vegetation.

The characteristics of the main channel in Subwatershed 18 have been influenced by the regulated flow regime. The channels are generally classified as 'C-type' and the lower sections as 'B-type' and are fairly stable. There are sections where the overall stability is not as good. Upstream, above the Alton branch, cattle access has resulted in poor bank definition and higher sediment contributions. The reach upstream from the Caledon Creek exhibits some unusual channel forms, which are likely due to some channel alteration (dumping of sediment or channelization) over 50 years, from which complete adjustment of the watercourse has not yet occurred.

Some of these unusual forms and areas of channel instability can also influence the sensitivity of the channel to alterations. These alterations can either be direct (channelized, hard structures) or indirect (flow regime, sediment dynamics). A channel with a high sensitivity will adjust or respond to slight or minor alterations and generally take longer to recover or stabilize. Reaches which are steeper or have coarser substrates are typically less sensitive than flatter channels with sand or silt substrates.

Terrestrial

Subwatershed 18

The areas of highest priority include the Credit River valley system and adjacent lands from Alton to the confluence with the West Credit River. This natural area includes the most diverse areas in the subwatershed containing; both macro corridors; a large percentage of core area and deep core areas and Class 1 communities (based on relative community size).

The Dufferin Lake area is also a significant natural area containing the only Provincially Significant Life Science ANSI in Subwatershed 16 or 18. It also contains habitat for an endangered species and three Class 1 communities (based upon relative community size).

Another important area is Forest Conservation Area #1 and the adjacent area. This area is highly diverse, containing four Class 1 communities (based upon relative community Size); a community with trees greater than 125 years of age, and is a source area for tributaries in both Subwatershed 18 and Subwatershed 15.

Subwatershed 16

The most important areas within Subwatershed 16 are the headwater areas of Caledon Creek, particularly in Concessions 3, 4 and 5 EHS, north of 15th Sideroad. These areas contain the only 200 metre core areas in the entire subwatershed; are part of the Provincially Significant Speersville Wetland Complex, and have many Class 1 Communities (based on relative community size).

Another significant area is the natural area north of the Village of Caledon. This patch is relatively diverse but a majority of the area consists of Class 1 communities (based on relative community size). As well, the area contains some 100 metre core, and is classified as the locally significant Caledon Village Wetland.

Aquatic

Subwatershed 16

In all, 19 fish species reside in Caledon Creek. Caledon Creek is dominated by species considered to be tolerant of a range of environmental conditions. This is reflective of the intermittent nature of this subwatershed but also suggests the importance of permanent flowing reaches or pools and wetlands to provide seasonal refuge.

The most sensitive species, particularly with respect to groundwater gradients into the stream, are brook trout, which are only found in the lower reach of Caledon Creek where permanent baseflow exists. The provincially significant species redside dace was sampled in one tributary of Caledon Creek and are indicative of cool water conditions along with another coolwater species the rainbow darter.

Subwatershed 18

Twenty-four fish species reside in the Credit River. Healthy brook trout populations reside in the downstream half of the Credit River within the study area. The most critical spawning habitat identified is just north of Highway 24. Populations in the upper half are restricted to smaller "refuge" areas. Historical and recent data suggests the area just downstream of 20th Sideroad has seen a disappearance of the local brook trout population. Downstream of the Cataract Falls brown trout coexist with the brook trout population. Both are wild self-sustaining populations that provide a high quality recreational fishery and serve as environmental barometers.

Protection and rehabilitation strategies of the fishery should focus on groundwater contributions, thermal impacts from ponds/impoundments and areas lacking riparian cover, predation from northern pike and stream morphology south of 20th Sideroad.

Water Quality

Sites where water quality is excellent were generally located in headwater areas. The headwater tributaries of Caledon Creek, the majority of the upstream portion of the Credit River and the reach of the Credit just upstream of the Forks of the Credit have excellent water quality.

In contrast, sites with poor water quality include the downstream portions of the tributaries of Caledon Creek east of Heart Lake Road, and the tributaries to the upper part of the Credit.

Factors that can influence water quality include groundwater inputs, presence of on line ponds and wetlands, the presence of riparian vegetation, and the adjacent land use. It should be noted that the results of the Hilsenhoff Biotic Index can be related directly to the aquatic communities.

Summary of Findings

The combination of the Singhampton Till layer, in close association with the Amabel bedrock formation and the Caledon Meltwater channel create what appear to be a regionally significant recharge and storage area for several subwatersheds. The location and slope of the Caledon Meltwater Channel in association with the elevation and slope of the Amabel bedrock formation create an enormous opportunity for groundwater discharge into specific reaches of Subwatershed 18. The location, character and shape of the Caledon Meltwater channel creates a "Horn of Plenty" shape facing towards the Credit River. Consequently it is not a coincidence that the best coldwater habitat, highest productivity of trout and best spawning areas for brook trout are found in this reach of river.

The dampened pattern of high flows in Subwatershed 18 which result from both the geology and the large riparian forests, create very stable channel forms for fish habitat, while the distribution of groundwater flow to streamflow provide good conditions for fish communities. The upper sub-basin of Subwatershed 18 contains good fish habitat and temperatures quite suitable for a coldwater community dominated by brook trout. The middle sub-basin contains less groundwater activity and has potential for a coldwater community, although habitat appears limited because of unusual channel structure. The lower portion of the sub-basin contains high quality fish habitat, active spawning, medium to high biomass of trout and ample amounts of groundwater, a result of the significant contributions of groundwater from Subwatershed 16 and to a lesser degree Subwatershed 15.

Three major geographic forms occur in the two subwatersheds and provide the opportunities for terrestrial species diversity and richness: riverine corridors, till plain and hummocky till plain, and buried Niagara Escarpment. Of these three units, the first two generated the highest priorities for protection, based upon a comparison of: communities or patches; community class; core characteristics; "natural" forest and/or wetlands.

The aquatic system within the two sub-basins are very different from each other, based upon the characteristics of geology, groundwater movement, surface water flow and land cover. Fish community distribution is based upon a number of factors: flow regime (flow stability and base flow volumes), thermal regime (seasonal temperature maximum, minimum and means), structural habitat (channel morphology and groundwater discharge areas), land cover in the riparian zone (contributions of nutrients to the stream, shading, contributions of woody debris, contributions to channel and bank stability and fish community dynamics).

Water quality throughout the two subwatersheds, (based upon an analysis of invertebrate populations) is generally good. The best water quality found in Subwatershed 16 is found in its headwaters, associated with forested and/or wetland features, whereas the poorest water quality is found in the lower tributaries of Caledon Creek and east of Heart Lake Road, associated with more active land uses.

Subwatershed 18 appears to be an extremely healthy, productive and stable subwatershed. Aquatic productivity is generally high, water quality is good, and terrestrial features are in general intact, despite the fact that this subwatershed is within one hour drive of over 3 million people. Overall health is a direct result of the recharge and storage characteristics of Subwatershed 16. The characteristics and quality of Subwatershed 18 rely heavily on the recharge and storage capabilities of Subwatershed 16 and the maintenance of an intact riparian system along its valley. Alterations in the functional characteristics of recharge and storage in Subwatershed 16 should be carefully assessed in order to avoid altering the quality and quantity of groundwater moving from Subwatershed 16 into the other adjacent subwatersheds.

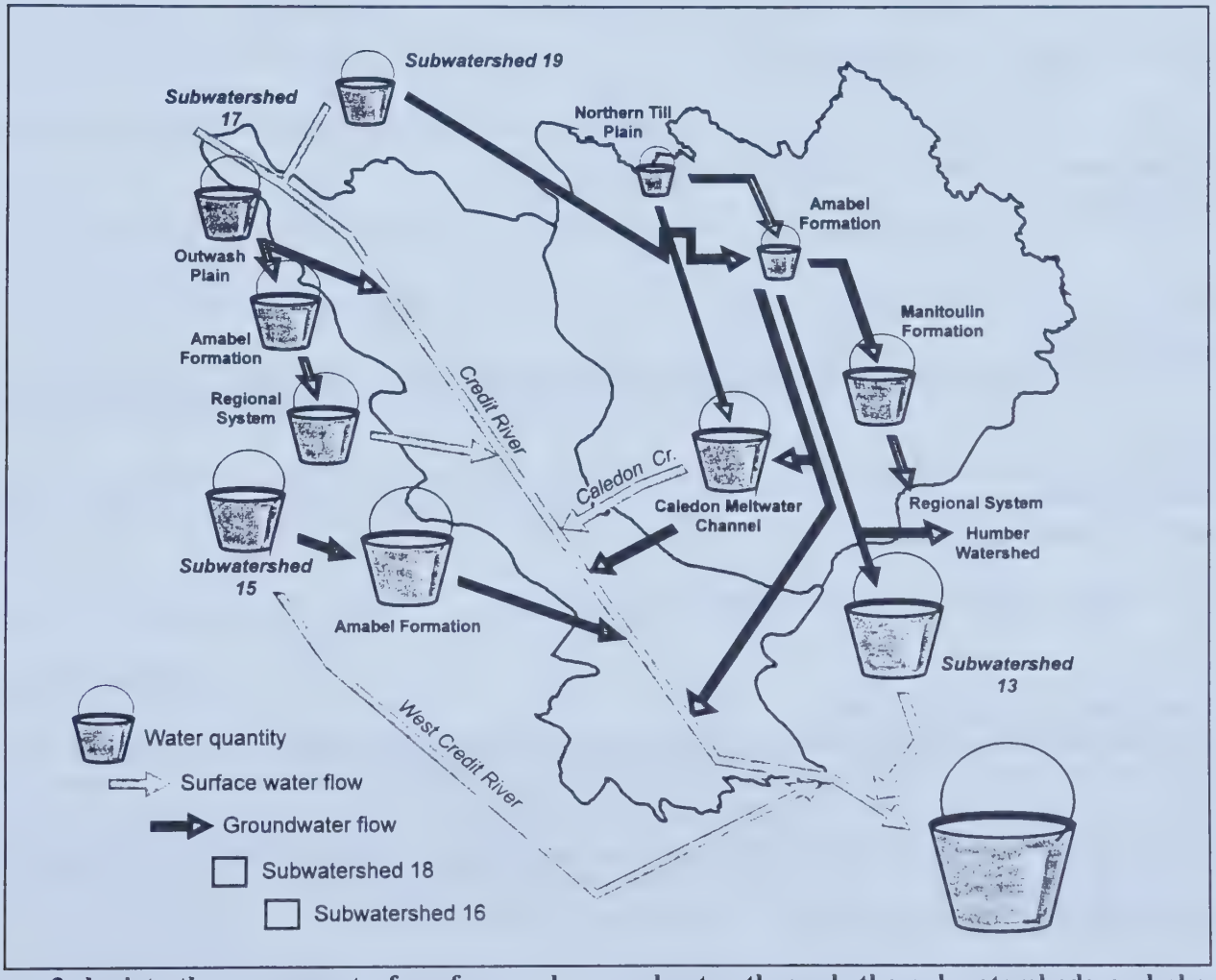


Figure 2 depicts the movement of surface and groundwater through the subwatersheds and shows the important water linkages.

The quality of the fish community and specifically the trout community of Subwatershed 18 relies fundamentally on the recharge characteristics of Subwatershed 16 and the valley shape, discharge characteristics and riparian characteristics of Subwatershed 18.

Goals and Objectives

The vision and goals for Subwatersheds 16 and 18 were developed with the assistance of the Focus Group. The technical committee have also had input and have since endorsed them. The vision and goals will be consulted if future restoration or rehabilitation work is planned.

Vision

Our vision of the Caledon Creek and Credit River Subwatersheds includes the protection of the natural features and functions that exist today (1997) as well as the enhancement of natural features and functions where they most benefit the overall environmental health of the area.

Consistent with this vision, is our desire to keep the character of the countryside of these two subwatersheds in balance with the use of the resources within the subwatersheds.

Goals – Subwatershed 16 – Caledon Creek

PROTECT
- existing important natural features and functions
- groundwater

MAINTAIN
- existing functions of the water flow system
- coldwater fishery
- communication with subwatershed residents and other interested parties on the health of the subwatershed

ENHANCE
- coldwater fishery
- natural features and functions

RE-ESTABLISH the riparian vegetation upstream of the gravel pits

RESTORE
- stream channel in aggregate areas
- damaged or degraded natural features and functions (use gravel pit restoration as an opportunity)

PROVIDE
- recreational and interpretive opportunities (use gravel pit restoration as an opportunity to add to public open space in critical areas)
- support for private land stewardship

ENCOURAGE, where feasible and practical, suitable agricultural practices that acknowledge compatibility of production with riparian habitat

ESTABLISH a monitoring program to detect and report changes to the community and decision-makers about the environmental conditions within the subwatershed

Goals – Subwatershed 18 – Credit River

PROTECT
- existing important natural features and functions
- groundwater

MAINTAIN
- existing functions of the water flow system
- self sustaining coldwater fishery
- communications with subwatershed residents and other interested parties regarding the health of the subwatershed

ENHANCE
- self sustaining coldwater fishery
- natural features and functions

RESTORE damaged or degraded natural features and functions

PROVIDE
- recreational and interpretive opportunities (use gravel pit restoration as an opportunity to add to public open space in critical areas)
- support for private land stewardship

ENCOURAGE, where feasible and practical, suitable agricultural practices that acknowledge compatibility of production with riparian habitat

ESTABLISH a monitoring program to detect and report changes to the community and decision-makers about the environmental conditions within the subwatershed

Subwatershed Impact Assessment

Proposed Methodology

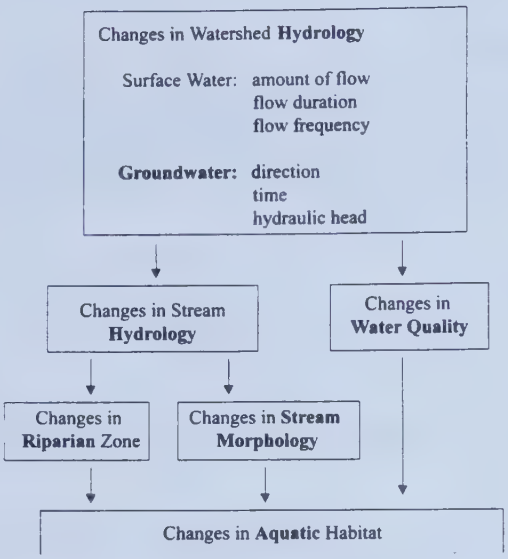
The underlying principles behind the impact assessment deal with the issues of scale (spatial and temporal), development of a stress-response framework and sensitivity testing. The scale of the impact assessment will be carved out at the subwatershed level. Spatial analyses will be limited to a subcatchment and associated stream reach. A stress-response framework was selected by utilizing three landuse conditions. These three conditions represent existing 1998 conditions, a future interim landuse condition (sensitivity test 1) and an ultimate landuse condition (sensitivity test 2). The future landuse changes include increased urbanization and aggregate mining, and decreased land uses.

All three conditions were modeled using hydrologic models to establish impacts to groundwater and surface water flow regimes. The flow chart shows how these impacts are translated to the other environmental components and ultimately to the aquatic system, which are being used as indicators of watershed health.

This analysis is currently underway and will be completed in early fall.

Public Participation

Environmental Impact Model
as Defined by Water Linkages



A Communications Committee was formed at the onset of the subwatershed study process. The purpose of the committee was to seek out and encourage public involvement throughout the study process. In order not to confuse the public with other ongoing initiatives, public meetings were jointly held with these initiatives. Short presentations were made to such groups as the Ratepayers Association, Women's Institute, Optimist Club and a local Environmental Advisory Committee. Historically, the relationship between those involved in the aggregate extraction industry and approval agencies has not been ideal. Therefore a meeting was convened with the major aggregate operators in the subwatershed to determine how they wish to be involved in the process. Analyses were also undertaken using the municipality's Tax Assessment information to determine the types of land use and therefore determine the target audience for contact. This also assisted in developing a mailing list to contact those landowners whose properties were selected for fieldwork to collect additional data. A landowner contact process was initiated and a protocol was developed in order to outline landowner permission, sharing data collected and keeping the landowner informed of the progress of the study. In addition, a 30 member Focus Group was formed exclusively to the study. The groups role is to receive study results and participate in discussions regarding local knowledge, provide reactions to findings, assistance with the generation of a Vision and Goals for the study area, as well as feedback on policies and priorities.

Other smaller initiatives included a contest held at the local public school to design the study logo. A field trip was held for the environmental club of the local high school to participate in streamside benthic identification. Local residents also participated by measuring waterlevels at established locations after heavy rainfalls. These events were also covered by the local newspapers.

Future Work

The study is ongoing and will be completed in approximately two months. The Impact Assessment will be completed and mitigation measures reviewed and selected using the established Goals and Objectives. Following this the Implementation phase will be initiated and will be developing a clear action plan with assigned responsibilities for the coming years.

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Community Involvement In Reclamation and Urban Ecology Restoration

Dan Napier

Regional Municipality of Sudbury
Land Reclamation Program

The Regional Municipality of Sudbury is located in northern Ontario. A community of over 164,000 people, Sudbury is a centre for mining, smelting, refining activities, mining related manufacturing, research, health services, colleges and university, and government services. Sudbury, is also a service centre for Northeastern Ontario and serves as a transportation hub.

The Regional Municipality of Sudbury's Land Reclamation Program is well known to the Society for Ecological Restoration. The Land Reclamation Program is very successful and has truly helped to transform the Sudbury landscape over the past decade. What was once barren land, with black rock, is today a treed landscape. What was once a landscape suffering, is today a landscape that is thriving and flourishing. What was once a community with a negative reputation, is today a community gaining popularity.

The Regional Municipality of Sudbury initiated its Land Reclamation program in 1978 to restore damaged lands within its urban communities and along its road corridors. Today over 3,200 ha of the most damaged land have been revegetated with grass cover, through the application of lime, fertilizer and seed. In these same areas 4,400,000 trees comprising of 15 different coniferous and hardwood species have been planted.

Carried out under the Region's sponsorship and administration, the program has provided short term employment opportunities for over 3,500 students and unemployed individuals. Program costs exceed 17 million dollars with funding primarily obtained through a wide variety of government grant programs and private sector contributions.

Community Involvement...A Success

In 1992, the Regional Municipality of Sudbury was recognized and received the United Nations - Local Government Honours Award. This is but one of many prestigious awards the Program has received through out the years to recognize the Programs accomplishments and the transformation of the Sudbury landscape. These awards, and the success of the Program would not be possible, if it wasn't for the hundreds of people involved.

The Regional Municipality of Sudbury's Land Reclamation Program is truly a "Community Partnership". This partnership extends to many levels. Community involvement starts with the planning and administration of the program and continues to the actual implementation.

Community participation in the program includes:

Planning
- Development of 5 year Plans
- Site Selection and planting locations
- Program Marketing and promotion
- Technical information
- Program direction and strategic planning
- Public awareness
- research and monitoring
- funding for program operation
- long term funding strategies

Program Operation
- tree planting
- application of lime, fertilizer and seed

Vegetation Technical Advisory Committee (VETAC)

Most of the community involvement for the Planning activities are generated through an established committee. In 1972, the newly formed Regional Municipality of Sudbury created a "Technical Tree Planting Committee". In 1974, the Committee funded a survey to assess vegetation damage along main roads and railways. Joint work between the Ministry of Natural Resources and Laurentian University (Sudbury) showed that manual application of limestone, fertilizer and seed led to the establishment of grassed plots. In 1975 and 1977, semi-operational 0.5 ha plots were successfully grassed by schoolchildren. In 1978, in response to an economic downturn, the "Technical Tree Plant Committee" proposed a land reclamation program. The Committee's name changed to the Vegetation Enhancement Technical Advisory Committee (VETAC) in 1978, to better reflect its broadened mandate.

VETAC meets monthly and has the status of an Advisory Committee to The Regional Municipality of Sudbury Regional Council. Currently there are 26 members on VETAC. Each member sits on the main Committee as well as volunteering time to a sub-committee. The sub-committees are the working committees where ideas are explored and developed. These sub-committees include:

Program Operation:

This committee looks at the programming of the program, including timing, locations to be planted and areas to be "treated" and "greened". In addition this sub-committee researches and explores technical aspects of the Program including application rates and plant specie selection.

Research and Monitoring:

This committee oversees the monitoring and research aspects of the Program. This includes exploring success rates of the living plant materials. In addition this committee develops test sites to explore various application techniques to determine if our practices and procedures can be improved.

Education/Communication

This sub-committee develops and outlines promotional and educational aspects for the Program. Some of these initiatives include production of brochures, data sheets, display boards and signage. This committee is currently developing a video and web site on the Program.

Finance

This sub-committee is working to provide funding for the initiatives of the other sub-committees. These finances are not used for the yearly operation of the Program. Various fundraising strategies are developed and implemented by this committee.

Each sub-committee works on their own projects according to their own schedules and time commitments. All of the sub-committee's work is presented to VETAC for comment and approval. All VETAC activities are ultimately sanctioned by the Regional Government.

The Vegetation Enhancement Technical Advisory Committee (VETAC) is made up of volunteers and interested individuals from the community. These individuals bring a wide range of knowledge and expertise to the table. Members on the committee represent government, business, industry, academia, or are individuals who have a genuine interest in the Land Reclamation Program.

Government Partners

Government participation in the program varies from year to year. Government funding is generally for labour and provides opportunities for unemployed or underemployed individuals. In addition several government agencies provide technical expertise as well as materials and equipment.

Mining Companies

INCO and Falconbridge Limited provide financial assistance, materials and equipment as well as technical expertise.

Clubs and Organizations

Various clubs and organizations assist by planting trees and/or by adopting a parcel of land. Many groups adopt an area for several years, liming the soil, applying fertilizer and seed followed by tree planting.

Schools

School groups both elementary and secondary assist the program by liming and tree planting. The program also involves students from other parts of the Province, who are visiting the City on class excursions. These students plant trees and learn about Sudbury's Program and the history of the Sudbury region as a part of their class trip.

Private Companies

Several private businesses have provided financial contributions, material, equipment and/or labour.

Interested citizens

Many citizens of the Region of Sudbury volunteer their time to plant trees. Individuals are usually asked to join an organized group on a planting day.

Academic

Laurentian University, Cambrian College and College Boreal assist the program by providing the Committee, technical expertise and support. As well, ongoing monitoring of the program and use of equipment /facilities have been provided as required.

Why the community is involved?

By far, the most important reason why individuals volunteer there time to the Land Reclamation Program is that they feel a sense of accomplishment in the work and believe in the program. Many people who volunteer their time to the Program grew up in the region and have noticed an improvement in the local environment. These volunteers remember the "black rocks" and have witnessed the transformation of the environment. For them being part of this change is rewarding and meaningful.

Since the program has been operational for over 15 years, the efforts of past work are now showing. The trees that were planted over 10 years ago on treated lands, are now reaching heights of over 15'. These trees are a continual reminder to the community that the Program works. Realizing that the program is successful, the community supports the programs continuance and yearly activity. A sense of pride is illustrated as volunteers discuss their past tree planting efforts and how they can see how the trees have grown.

The communities interest in the environment does not stop with the Land Reclamation Program. An "environmental awareness" attitude has surfaced in the community. This attitude has lead to, an increase in environmental groups and organizations, an increase in landscaping on both business and residential properties and an environmental focus for new developments. This awareness has recently sen the creation of a "Community Enhancement Award" program, recognizing landscaped developments and environmental initiatives.

How do we encourage community participation?

Each year an annual "Tree Giveaway" is held. The purpose of this event is to communicate to the community the efforts of the program. In addition to giving away trees, displays illustrate the effects of the Program, and brochures and information are provided on the Program. By illustrating "before" and "after" photos, the community is reminded of "what once was". This event draws many people who wish to volunteer their time and/or donate to the Program.

Efforts to show appreciation to the many volunteers area also important. Appreciation Ceremonies, recognition plaques, barbecues, and thank you letters are all used to express thanks to the many who volunteer there time to the Land Reclamation Program.

Tools you need for community participation

The fact that the program operation has remained "flexible", has allowed us to take advantage of several opportunities. Given the fact that we are prepared to accommodate either large or small groups, we are able to work with many groups. We also strive to meet the requirements of the group wishing to assist with the program. This means being available to meet their time schedule, providing them with the equipment and material they need, and providing them with direction and supervision.

In addition to being flexible, we have also found that being prepared is a key to be able to capitalize on available opportunities. We encourage the development of a Plan or Proposal for a particular aspect of the Program, even if we do not currently have the finances to make that project a reality. By having the project well thought out and developed, it is easier to try to gain funding and/or take advantage of a financial opportunity as it arises. This also encourages many of our volunteer committee members, to remain open and interested in developing and working on projects. As projects become a reality, those volunteering their time to develop the idea, feel a sense of accomplishment, and are encouraged to continue to work with the Program to see other results.

Challenges

Working with the community is very rewarding and satisfying. The efforts and results are shared, and become more meaningful and complete. However, working with volunteers creates its own set of "challenges". One of the biggest issues is the time factor. Meeting others' schedules and including them into the decision making process all takes time. Often the commitment by volunteers is sincere, but cannot be honoured. A group may only be able to rally half of the individuals they thought they originally could get, or may not be able to show up at all. All of this may occur as a last moments notice, or even not at all.

Another issue, is the quality of work completed. Some of this work may be completed very well and other volunteer work may not be very successful. We know with our tree planting, for example, that the survival rate for our trees is less than when planted by our paid workers. The survival rate appears to decrease with the age of the volunteers. For example, elementary school children often plant several trees in one hole.

Overall, the benefits of working with the community far out way the many challenges. The more people educated and involved in the program mean we have more advocates and supporters of the Program. Community involvement in environmental programs creates a sense of pride in individuals and this pride translates into an ongoing environmental consciousness . With financial burdens facing all of us, community involvement is one method to ensure projects are completed.

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MANAGING FOR NATURAL AND CULTURAL HERITAGE AT RED CLOUD CEMETERY PRAIRIE

Larry Lamb

Faculty of Environmental Studies
University of Waterloo

ABSTRACT

Red Cloud Cemetery Prairie is laced near Castleton, Northumberland County, Ontario. This relatively fine Rice Lake Plain sand prairie remnant has been severely impacted by cemetery plots, the establishment of a memorial red pine grove, escaped invasive alien materials planted at grave sites and by fire suppression.

Over the past four years management efforts toward fostering both the development and promotion of the tall grass prairie and the cultural heritage of the cemetery have been "undertaken". Efforts specific to prairie restoration include: base data collection and monitoring, red pine removal, a burn, invasive alien species removal and the production of an interpretive brochure.

Priorities of the Red Cloud Cemetery Board are the conservation of the grave markers, the memorial pine grove, poison ivy control, and the establishment of a trail network to facilitate access to the tombstones (as well as to the prairie).

A delicate balance between conserving the prairie and maintaining the cultural heritage has made for a challenging involvement at Red Cloud.

A history of the involvement of the cemetery board, volunteers, researchers and funding agencies involved with management of this truly unique site (for Ontario) will be presented.

THE ALEX WILSON COMMUNITY GARDEN

Lorraine Johnson

Chair, Alex Wilson Community Project

ABSTRACT

The Alex Wilson Community Garden is an urban greenspace combining food-growing allotment plots with naturalized areas (representing a lakeshore planting, an agricultural hedgerow and a woodland) in downtown Toronto, at 552 Richmond Street West. The garden was created by a volunteer group, the Alex Wilson Community Project (AWCP), which began meeting in 1993 in order to create a permanentcommunity garden in honour of the late ecological restorationist Alex Wilson (author of The Culture of Nature).

The AWCP secured a land donation for the garden, held a design competition for the garden, held an exhibition of all designcompetition entries at the Design Exchange, built the garden and is now administering the garden on land that has been donated to the city of Toronto, with a unique conservation easement attached tothe donation to ensure that it remain a community garden andnaturalized area in perpetuity.

The Alex Wilson Community Garden, an urban greenspace combining food-growing allotment plots with naturalized areas in downtown Toronto, officially opened on June 20, 1998, the day before the summer solstice. The solstice has special meaning for the volunteer group that spearheaded the garden, the Alex Wilson Community Project (AWCP). A year prior to the opening, in 1997, we held our groundbreaking ceremony to begin construction of the garden on the summer solstice. And on the same day in 1996, the group held a brainstorming session (at a bonfire in the country)--a planning event at which everyone in the group talked about our hopes and dreams for the garden. In this paper, I'll discuss the process we went through between bonfire and official garden opening, how this community garden came to be, the philosophy behind it, and some of the practical challenges we dealt with in creating the garden.

I should note, however, that although the AWCP endeavoured from the beginning to fashion the project as a model that could be used by other groups wishing to start a community garden or naturalized area, the project has a number of unique features that undoubtedly contributed to our success but that make it somewhat less of an accessible model for other groups to follow. (In particular, the AWCP was able to secure a permanent land donation for the garden.)

* * *

As many of you know, Alex Wilson was a landscape designer actively involved in ecological restoration as both a theory and a practice. He wrote The Culture of Nature (Toronto: Between

the Lines, 1992) and his work was an inspiration to many. One quotation from his book articulates his intellectual and practical project: "We must build landscapes that heal, connect and empower, that make intelligible our relations with each other and with the natural world: places that welcome and enclose, whose breaks and edges are never without meaning. Nature parks cannot do this work. We urgently need people living on the land, caring for it, working out an idea of nature that includes human culture and human livelihood." (Alex Wilson, The Culture of Nature)

When Alex died in 1993, a group of his friends and associates came together, at the urging of Lori Spring, to discuss ways in which to create a permanent memorial to Alex in the form of a community
garden.

Alex had been instrumental in starting a small community garden in his neighbourhood, the Stafford Street Community Garden, a few years earlier, on a vacant lot beside his house. The garden had combined a common area landscaped with native plants and food- growing allotment plots used by people in the community, including clients of a local social service agency for homeless men.

Initially, the AWCP focused on the Stafford Street site. The owner of the vacant lot had recently put the land up for sale and we devoted our energies to convincing the city of Toronto Parks Department to buy the land and turn it into a permanent community garden in Alex's name. We enlisted the support of our local councillor and negotiations were progressing well, but slowly. Unfortunately, the land was purchased by a developer. The AWCP decided to explore other options, such as creating a community garden on a different piece of city-owned property.

At this point, we did not have a clear sense of what the restoration goals of the garden would be--we felt that we needed to wait until we had an actual site to begin this discussion. However, we were working on the assumption that the community garden, wherever it might end up being, would include both a native plant component and food-growing allotment plots.

Within weeks of losing the Stafford Street site, we were approached by Dianne Croteau and Richard Brault, owners of an industrial design firm, Studio Innova, in the Bathurst and Queen street neighbourhood. Richard and Dianne owned a parcel of land at 552 Richmond Street West. They had built a live-work studio on part of the property and were considering their options for the adjoining vacant lot. They decided that they wanted their property to be a community garden and approached Laura Berman of FoodShare (and also an active member of the AWCP) for suggestions.

From our first meeting together, it was clear that Richard and Dianne were offering a generous gift of spirited enthusiasm along with an unparalleled gift of land. They propelled the project forward in a way none of us could have imagined or anticipated. They were offering us land for a permanent garden, they were interested in exploring unique ownership options for the garden, such as a land trust, and they were committed to becoming active participants and partners in the project. Together, we entered a new phase in the life of the AWCP, a phase that would not have

been possible without the generosity and vision of these two unique individuals.

* * *

"Restoration is not just for experts. It's very much a vernacular science that can be carried out by ordinary people working in the places they inhabit."
--Alexander Wilson, CBC IDEAS, "Restoring the Earth"

Due to the fluid and rather informal nature of the AWCP (we had applied for and received non-profit, registered status as a group, but we didn't have formal rules for membership), each participant brought their enthusiasm, skills and passions to the table. I believe that one of the main reasons for the successful completion of this project was the diverse interests of the members involved. Some members were knowledgeable about native plants and restoration; some were knowledgeable about community gardens and city politics; other members included a filmmaker, a lawyer, local business people, artists, architects, designers, a contractor, an educator. Members were free to devote as much or as little time as they could to the project. In short, a broad range of interests and enthusiasms kept our group vital and we called on different areas of expertise as needed.

For example, Richard Brault and Dianne Croteau are industrial designers, and one of the conditions of their land donation was that the group hold a competition to design the garden. It is with the design competition that our project steered in a direction that is perhaps not one most community gardens would choose to follow. (I know of no other community garden in the Metro Toronto area that has done something similar, as most community gardens develop using the design expertise of their existing members rather than launching an outside competition.)

However, the competition had a number of very real, tangible benefits, along with a number of organizational challenges, and I would recommend a design competition to groups with a solid core of committed members. First of all, the design competition forced us to clarify our goals for the garden: together, we agreed that we wanted to include both a native plant restoration area in the garden and food-growing allotment plots.

Along with focusing our ideas for the garden, the design competition also encouraged us to forge new and expanded partnerships, which in the long term have contributed a great deal to the AWCP. For example, we contacted both the Design Exchange (a Toronto museum and reference centre devoted to promoting design) and the Ontario Association of Landscape Architects, and asked for advice and assistance in running a professional design competition. Both organizations provided logistical help, mailing lists, promotional assistance, and helped to educate us about proper competition procedures. The Design Exchange (DX) became further involved by offering us exhibition space to mount a display of all the competition entries, and by providing a space for competition judging.

Another extremely important feature of the design competition was that it spurred a large number of professional and student landscape designers to think about ecological restoration in the urban context and about community gardens. I believe that in terms of outreach, this was one of our

most successful achievements: over 65 teams of landscape designers who entered the competition represented hundreds of people who were devoting creative energy, some for the first time, to the unique challenges of designing a native plant landscape and community garden.

Likewise, the decision to hold an exhibition of the design competition submissions at the Design Exchange also had far- reaching effects: thousands of people visited the exhibition (over 500 on the opening night, when we held an evening of slides, presentations, and the then-mayor of Toronto, Barbara Hall, congratulated the winners and the runners-up). Along with publicizing our particular group and the ideas about community life that propelled it, the competition and exhibition helped to publicize and promote the idea of community gardening and urban restoration.

In terms of analyzing what made the competition and exhibition successful, I think that our commitment to a professional process throughout was key. We solicited expert advisors for various aspects of the project, such as safety, compliance with by-laws, etc., and we enlisted the assistance of professional organizations. And, we were extremely lucky in that a number of our members already had expertise in key areas--e.g., design, writing, editing, exhibition curation, native plant landscaping and community gardening--and we could draw on this expertise as needed.

* * *

"...nature too has a history. It is not a timeless essence, as Disney taught us. In fact, the whole idea of nature as something separate from human experience is a lie. Humans and nature construct one another. Ignoring that fact obscures the one way out of the current environmental crisis--a living within and alongside of nature without dominating it."
--Alexander Wilson, The Culture of Nature

The winning design was created by Katherine Dugmore, Kent Ford, and John Holmes. The jury (made up of AWCP members and consultants) felt that their design best represented the goals of the garden and that it was doable within a budget of $80,000 (money, I should note, we had not yet secured). Perhaps the most appealing feature of their design was that, as one juror put it: "Their design tells a story." Incorporating the maximum space available for food-growing allotment plots, the design also leads through three native plant landscapes: a lakeshore planting of dune grasses at the south end of the garden (a reference to the nearby Lake Ontario shoreline); a meandering walkway bordered by an agricultural hedgerow (an acknowledgement of southern Ontario's productive farm landscape and its abandoned edges along fence lines); and a small wooded area at the north end of the garden (reminiscent of the forests that once covered Ontario).

* * *

"We now need a larger perspective. We need to gain a sense of how our constructed environment connects to the natural one surrounding it, and to its history. Only then can we be mobilized to restore nature and to assure it, and ourselves, a future."
--Alexander Wilson, The Culture of Nature

At the same time as we were running the competition, and then, after choosing the winning

design, dealing with the details of actually building the garden, the AWCP was involved in the extended and challenging process of deciding how best to secure the site as a permanent, publicly accessible garden. At this point, the land was owned by Studio Innova, and Richard and Dianne were committed to the idea of donating the land to some entity, either the city or a land trust, that would own and operate the garden in perpetuity as a community garden in honour of Alex Wilson. The discussion of how best to achieve this goal, and the exploration of the various options involved, took place over almost two years.

In the spring of 1996, the AWCP began meeting with Audrey Hollasch of the Toronto Parks and Recreation Department, to discuss the possibility of donating the land to the city in exchange for the city financing the construction of the garden. (The funding for the competition and for the exhibition, it should be noted, was privately donated.)

From the earliest days of these discussions, city budget constraints served as a stumbling block in the negotiations. Although the city had valued the land for tax purposes at over $200,000, they were willing to provide only $50,000 towards the construction of the garden (our construction budget for the garden, however, was $80,000), plus in-kind materials and services.

Initially, there was a sense of frustration within the group that such a unique opportunity for the city was not being valued more highly. However, we realized that it was up to our group to ignite enthusiasm at the city level, to forge a true sense of partnership and shared mission.

We achieved this at both the bureaucratic and political level by involving city people in our discussions: our councillor's assistant regularly attended meetings and we consulted with city engineers about various aspects of the garden. Basically, we simply continued to forge ahead, trying to create a project that the city would want to be involved in. We weren't "fighting" city hall; instead, it was a process of building enthusiasm for the project within city hall.

With the Parks Department and our councillor "on side," the first step was to go through the Neighbourhoods Committee, which approved in principle a $50,000 grant (and in-kind services) in exchange for the land donation.

We still needed to work out the details of the management plan for the garden (ensuring community involvement and some measure of community control in the long-term maintenance of the garden—both of which are relatively new models for the city), and negotiate all the details of a complex land transfer (including a unique conservation easement attached to the land donation, to ensure that it would remain in perpetuity a community garden in honour of Alex).

However, we decided to start work on the construction of the garden even though these details were not in place. This represented some level of risk for the AWCP, as we had to take out a $50,000 line of credit to cover construction. If the deal with the city had fallen through, we would have had a large debt. The group felt comfortable with this risk, as the broad principles of our agreement had been discussed with the city at great length.

As well, there was one major benefit of doing the garden construction in the absence of finalizing

the agreement with the city and before transferring the land to them: the AWCP was in control of the garden construction. We consulted regularly with the city, drawing on their expertise around by-law conformity issues, water hook-up, etc., but the AWCP oversaw the construction (we hired a contractor and we solicited volunteers to keep costs down).

Through the experience of negotiating this agreement with the city, I would offer the following advice to other groups:

* Be prepared for the negotiation to take a very long time.
* Be very clear from the beginning what it is that you want the city to do and what it is that you want your group to control.
* Document everything on paper.
* Have a back-up plan that is doable in the event that city negotiations break down. (In other words, be committed to doing the project no matter what.)
* Try to find a lawyer who will do pro bono work for your group (our legal bills have been one of our main expenses).
* Work collaboratively and professionally with the city.
* Try to build enthusiasm with city bureaucrats and politicians-- work at partnership.
* If your group plans to have some measure of control over the site (maintaining naturalized areas, for example), try to address liability issues early on. (Ideally, the site would be covered under the city's insurance. In our case, however, because we have maintenance responsibilities, we also have liability--requiring a large expense, annually, for the group in terms of liability insurance.)

* * *

"If it's based in the communities people live in, ecological restoration holds out the hope of healing the breach between humans and the rest of nature."
--Alexander Wilson, CBC IDEAS, "Restoring the Earth"

There is a lot of talk, in volunteer projects, about partnerships. The AWCP didn't begin the project with a clear list of partnership opportunities to explore. Instead, we tended to develop partnerships as the opportunities arose and presented themselves. For example, the Earth Council Institute--Canada, through their connections with the Design Exchange, heard about the project and saw it as an example of community development at the local level. We started meeting and discussing ways we could forge a partnership. Not only has the Earth Council provided valuable financial assistance (enabling the AWCP to work with a contract employee to document all aspects of the garden's development), but our discussions with the Earth Council have also encouraged us to branch out into other areas (e.g., to conduct an economic and ecological evaluation of the garden's impact).

One of the most personally satisfying and, for the garden, crucial partnerships that has evolved has been with Portland Place, a social service agency that runs a non-profit housing complex, which is the garden's neighbour to the west. We began to meet with people in the neighbourhood,

informally, telling them of our garden plans, asking for input on the design, etc., and the people at Portland Place were enthusiastic about the garden. The director of Portland Place supported our proposal when it went through the Neighbourhoods Committee, but equally important to the actual garden itself has been the support and involvement of Portland Place residents.

Within a day of beginning construction on the garden site, a number of Portland Place residents became regular visitors and, within a few days, active participants and volunteers. Two residents assumed responsibility for watering the seedlings daily throughout the 30-day drought that began the day after we planted the native woodland plants.

Another Portland Place resident helped with planting the seedlings, as did volunteers from the Canadian Wildflower Society. One day, about 30 native plants mysteriously appeared, courtesy of another Canadian Wildflower Society member.

Another day, our first "guerilla" planting appeared: someone couldn't bear to see all that fresh topsoil go to waste, and so planted some squash in the allotment area.

Now that the garden has officially opened, it will no doubt take on a life of its own. The Alex Wilson Community Garden Corporation will oversee administrative details (assigning allotment plots on a first-come, first-served basis, ensuring that there's a group in place to look after the naturalized areas, etc.), but it is the gardeners themselves who will make this greenspace flourish. Although the land is now owned by the city, there's a conservation easement attached to the site so that it will always exist as a community naturalized area and food-growing garden, in honour of Alex Wilson, looked after by the community, open to all.

Naturalization of Landscaped Parkland at Ontario Hydro's Nanticoke Generating Station

G.R. McKenna
Senior Scientist
Environment Department - Fossil Business
Ontario Hydro

1.0 Introduction

Ontario Hydro is a provincially-controlled crown corporation that supplies over 90% of the province's energy needs. The Fossil Business operates six fossil-fuel facilities supplying approximately one-third of the provincial energy demand. Nanticoke GS, the largest coal-fired generating station in North America, was completed in 1978, and consists of eight generating units with a total capacity of 4000 MegaWatts. The station occupies 350 hectares along the north shore of Lake Erie, just east of Port Dover, Ontario. The undeveloped portion of 175 hectares consists of open fields under the transmission corridor and landscaped frontage. Nanticoke Park, a 30 hectare parcel in the northwest corner, has been the focus of naturalization efforts since 1995. As the technical resource for biological issues in the Fossil Business, I was requested by Nanticoke GS to co-ordinate and implement the program for the naturalization of Nanticoke Park.

Biodiversity and Ontario Hydro

In 1996 Ontario Hydro unveiled a Biodiversity Conservation Strategy with the explicit goal to "*plan and manage our activities in a way that encourages the continued existence of native species and the ecosystems on which they depend.*"(Ontario Hydro 1996). This document provided direction to the corporation, and was based on 3 key elements, Stewardship, Partnership, and Education. Three important sub-elements identified the priority regarding the stewardship of natural areas:

Retain natural areas where possible.
Restore those that have been degraded.
Replace (where feasible) those that are incompatible with our activities.

The corporate strategy directed all parts of the business to develop *Action Plans*. The Fossil Business developed site-specific plans tailored to the particular situation of each generating station. These plans made specific commitments to satisfy the key elements of the corporate strategy.

Biodiversity and Nanticoke Generating Station

The first step towards proactive naturalization efforts at Nanticoke GS was the completion in 1994 of a terrestrial field survey (McKenna and Torrenueva 1996). This survey provided detailed species lists of all woodlot and wetland areas. Birds were the main focus of the survey as ideal indicators of habitat vitality (Graber and Graber 1976, Towle 1994). Over 150 species of birds were identified either migrating through, nesting, or foraging in the onsite natural areas (McKenna & Torrenueva 1996).

A key recommendation was the naturalization of NanticokePark. While intended to serve onsite staff, the park was sparsely used, largely because of its remoteness from the main site. Nanticoke Park presented an ideal opportunity for a naturalization effort to complement the station's recently developed Action Plan.

Regional Setting

Nanticoke GS is located within the boundaries of the Deciduous Forest Region, analogous in many respects to the Carolinian Life Zone, of southern Ontario. This zone exhibits climatic and biological elements typical of more southerly areas. The proximity of Nanticoke GS to noted wildlife areas, such as Long Point to the west and Turkey Point to the east, situates it in an area of heightened ecological interest. Regional conservation activities include efforts to reduce habitat fragmentation.

The physiography of the station's location plays a key role in the character of its natural areas. The site is located on the Haldimand Clay Plain that dominates the eastern portion of the Haldimand-Norfolk region (Presant & Acton 1984). These imperfectly drained, heavy clay soils do not support the range of Carolinian elements seen in the Norfolk Sand Plain west of Port Dover. Woodlots on the Nanticoke property are typical of the Great Lakes-St. Lawrence Forest Region, and are predominantly White Ash, Basswood, Beech, Red Oak, Sugar Maple, and Shagbark Hickory (McKenna & Torrenueva 1996).

2.0 Naturalization of Nanticoke Park

Nanticoke Park consists of a triangular-shaped 30 hectare area located in the northwest corner of the plant property. It is bounded on the north by Regional Road 3 (Rainham Road) and on the west by Nanticoke Road 55. A service railway constitutes the "hypotenuse" of the triangle. The terrain is typically rolling upland, planted with groupings of conifers, hardwoods, or shrubs, dispersed among low-lying open areas. Landscaping was completed in 1973 using a mixture of nursery and ornamental stock with provincially native representatives. Non-indigenous species include Austrian Pine, Scotch Pine, European Mountain Ash, Norway Spruce, Russian Olive, and Tartarian Honeysuckle.

While not designed for habitat enhancement, limited wildlife activity was apparent during the 1994 biological survey. For the most part, birds foraging or nesting in the area were typical of urban or open areas (European Starling, American Robin), with few interior species detected.

Naturalization Strategy

Naturalization of Nanticoke Park began with passive naturalization of interior areas. This eliminated mowing in all areas beyond visual access from the road. A commitment was made in 1996 for an active naturalization program with the goal to create a regionally representative woodland for habitat enhancement and long-term regional habitat linkage. While passive naturalization would eventually achieve this, the station was interested in an active role to promote the values of biodiversity conservation. Progressive planting towards naturalization was designed to infill open areas and link the originally planted groupings.

The area was subdivided into distinct planting areas, identified as 1997, 1998, and 1999 of about 4 to 5 hectares in size. The most remote area was planted first (1997), working back towards the access road leading into the park. Existing detailed contour maps provided valuable drainage and elevation information. Planting of shrubs in visual gap areas was designed for screening and edge habitat.

Species Selection

Selection of species was based on two main references. The primary source was the 1994 inventory of onsite natural areas. Two woodlots provided guidance in selecting locally successful species. Composition in these

woodlots consists of Hop-hornbeam, White Ash, Sugar Maple, Basswood, Blue Beech, Shagbark Hickory, Red Oak, Nannyberry, Red-osier Dogwood, and Highbush Cranberry. Reference to local offsite areas was provided by the Natural Areas Inventory conducted by the Norfolk Field Naturalists (Gartshore et al 1987).

Seedlings (~ 18") were obtained from the St. Williams Forestry Station through the Long Point Region Conservation Authority. Table 1 lists the species used in the 1997 and 1998 planting efforts. Variation in species selection between the years was primarily influenced by availability of stock from St. Williams.

Table 1
Species Selection and Quantities

1997			1998		
Scientific Name	Common Name	Qty	Scientific Name	Common Name	Qty
Acer saccharinium	Silver Maple	2600	*Acer saccharinum*	Silver Maple	1000
Cornus sericea	Red-osier Dogwood	300	*Carya ovata*	Shagbark Hickory	500
Fraxinus americana	White Ash	700	*Cornus sericea*	Red-osier Dogwood	800
Fraxinus pennsylvanicus	Green Ash	2500	*Fraxinus americana*	White Ash	500
Juglans nigra	Black Walnut	150	*Juglans nigra*	Black Walnut	500
Larix laricina	Tamarack	350	*Pinus strobus*	White Pine	1300
Quercus rubra	Red Oak	650	*Quercus rubra*	Red Oak	1500
Thuja canadensis	White Cedar	750	*Thuja canadensis*	White Cedar	1200
			Viburnum lentago	Nannyberry	400
			Viburnum trilobum	Highbush Cranberry	400
	Total	8000		Total	8100

Site Preparation

Site preparation techniques for the initial 1997 planting consisted of fall ploughing and spring discing. While this risks weather-related delays in discing and possible difficulties with seedling delivery schedules, it is the recommended practice adopted by local farmers.

Mechanical planting in 1997 revealed the need to alter the site preparation process. As a maintained parkland for almost 25 years, the sod layer had developed a thick, resistant thatch. Despite ploughing and discing, thatch buildup prevented proper furrow closure during the mechanical planting, resulting in exposed roots for some of the seedlings. While partly remedied by subsequent heavy rainfall that closed many of these furrows, follow-up visits revealed evidence of seedling mortality. To reduce the extent of this problem, site preparation for 1998 included application of Roundup© in advance of fall ploughing. Because the 1998 planting was hand-planted, we were not able to observe differences in furrow closure.

A median strip of turfgrass was left intact throughout the site to permit future vehicle access.

Planting Methods

1997 Mechanical Planting

The 1997 planting area was 4.5 hectares in size, located in the northeast portion of the park. Approximately 8,000 trees were mechanically planted in 2 metre x 2 metre spacing. Mechanical planting uses a specialized wagon towed behind a standard farm tractor. Seedlings are inserted into the furrow opened by the blade. Angled wheels at the rear of the wagon close the furrow.

Species were grouped according to their suitability to upland, sloped, lowland, and wet conditions. Upland areas were planted with white ash, red oak, black walnut, white cedar, and tamarack. Sloped to low-lying areas were filled with green ash, silver maple, white cedar, and tamarack. The lowland drainage area was hand-planted with red-osier dogwood.

Generally, mechanical planting offered several advantages over hand-planting. Planting quality was better because of the knowledge and experience of the contractors. It is also more opportunistic for weather conditions, requiring less dedication to firm planting dates than is required for an organized volunteer event. Consistent spacing of seedlings permits easier survival monitoring and post-planting herbicide application.

1998 Hand Planting with Volunteers

The 1998 planting was hand-planted by the Haldimand District Scouts. Over 300 scouts, parents, and site staff planted approximately 7,000 seedlings in a 3-hour period on April 26, 1998. While generally, expectations of seedling survival are reduced for volunteer hand-planting, the Haldimand scouting organization was relatively experienced and trained. An instructional evening session was held prior to the event

Organizing and coordinating such a large-scale planting event required a method of allocating seedlings to their proper locations. To achieve this, seedlings were grouped as in 1997 according to terrain and drainage conditions and assigned colour codes:

Yellow (upland):	white ash, red oak, black walnut, white cedar, white pine
Blue (sloping):	silver maple, white ash, white cedar, shagbark hickory
Orange (lowland):	silver maple, white ash, white cedar, nannyberry, highbush cranberry, red-osier dogwood.

Maps showing the colour groups were provided to group captains assigned to each area. Generally, this organizing strategy worked well with most seedlings being allocated to the proper locations. The quality of the plantings was variable between areas, but on the whole was quite satisfactory. Orange groups (lowland) had to work in areas undisced due to wet weather. While the quality of volunteer planting is not ever likely to match mechanical planting, cost savings are an important consideration. The use of volunteers reduced costs by almost 50%, which can then be redirected into other aspects of the project.

One of the difficulties encountered was the allocation of seedlings between common colour areas. The distribution of stock was based on bundles of fifty. Unfortunately, the quantities per delivered bag were not easily split for planned allocation. The result was that, while most species were planted in the assigned colour zones, the desired arrangements and mixtures in each area were not possible. Plans to alternate rows of red oak and white pine, two complementary species, were achieved to some extent, but had to be eventually abandoned because of lack of one or the other in the immediate planting area. In any event, row planting in a volunteer hand-planting operation of this size proved a difficult task.

In addition, our assessment is that volunteer planters, especially younger children, tire rapidly and have a "enthusiasm window" of about 2 hours. Future volunteer events will likely be scaled down. In spite of these factors, approximately 7000 of 8100 seedlings were successfully planted in 1998.

Post-planting Tending Methods

Plans for post-planting tending in 1997 included herbicide treatment and mowing between rows to reduce competition and girdling by voles. In June of 1997, Roundup© was applied around each seedling using a

protective "stovetop" canister. This proved to be very effective, with essentially 100 % clearance of competition within an approximately 0.3 m radius. This clearance has been relatively maintained into the summer of 1998, even in the absence of further herbicide application.

Experience with mowing was not as good. Although the 2 metre row spacing allowed mechanical mowing, it proved difficult to stay within the open areas once the field vegetation reached heights above the seedlings. Several rows of seedlings suffered damage from the mower blades or tractor wheels before the effort was abandoned. In hindsight, the herbicide application provided both adequate protection on its own to control competition and provide sufficient open space to deter girdling.

Survival Assessment of Planted Areas

Evaluation of seedling survival was only conducted for the 1997 planting, since the 1998 effort is too recent to provide any solid data. A more rigorous, statistically valid assessment is pending, but a general live/dead assessment of the 1997 planting area produced an overall survival estimate of 57%. Nine plots (n=10) were allocated between the upland, sloping, and lowland planting zones. Survival ranged from 20% to 80% between the plots. Only survival (live/dead) was noted, and the evaluation did not include indication of seedling health.

A visual inspection of the 1998 planting was conducted with the Haldimand-Norfolk Rural Stewardship co-ordinator and the Haldimand Woodlot Owners representatives. Generally, seedlings appeared healthy, and the consensus was that long-term survival will be good. Dry weather in 1998 has caused excessive cracking in the heavy clay soils that may cause desiccation and exposure of seedling roots.

Follow-up survival assessments in 1999 using standardized random methods will provide a good indication of the success of each planting method.

Scientific Research Initiative – Mulching Trials with Zebra Mussel Shells

The naturalization of Nanticoke Park has allowed the initiation of some co-operative scientific research. Of particular interest is the extension of orchard tree mulching research to forest seedling assessment. In 1995, the Horticultural Experimental Research Station, located in Simcoe, Ontario was contracted to investigate the benefit of zebra mussel shells to orchard and cash crops. This was part of an initiative to divert this material, collected at the station intake pumpwells, from landfill. Results of mulch trials revealed a significant increase in soil moisture over standard straw mulches and controls (Cline 1998), translating into improved tree health.

A logical extension of this work was to assess the benefit to forest seedlings. In the fall of 1997, researchers established plots, applying shells to various depths. Data on the health, growth, and survival of mulched and unmulched seedlings will be gathered over the next 2-3 years. Preliminary data so far indicates that seedling health and survival for mulched plants is significantly superior to unmulched plants. A "non-scientific" visual assessment reveals a vibrant and healthy stand of seedlings in the mulched plots. Desiccation and cracking of the clay topsoil is minimal compared to unmulched plots.

3.0 Summary

The naturalization of Nanticoke Park has been a ongoing learning experience. Methods of site preparation, planting organization, and tending, are being refined and improved as the project progresses. The main lesson learned from the two years of successive planting is the influence of site-specific factors in determining optimum planting strategy and methods. The process is iterative, requiring integration of local knowledge and sharing of

experiences. Naturalization of Nanticoke Park has provided valuable insight to site-specific factors and overall strategy. Our experience has taught us that:

1. Site preparation of heavy clay soils requires a fall ploughing and spring discing strategy.
2. Site preparation for well-established sod & turfgrass may require herbicide (Roundup©) to loosen the sod layer and improve soil consistency to allow proper furrow closure during mechanical planting.
3. Mowing between rows is not recommended, unless there is adequate visibility of seedlings.
4. Tending with Roundup© is effective for both weed control and clearance to reduce grazing by voles.
5. Volunteer plantings that involve children should not exceed 5000 seedlings per 300 persons.
6. Colour-coding of species groups is an effective way of organizing a planting. However, advance knowledge of packaging is needed to split the stock into the allocated planting zones.

Overall, the naturalization of Nanticoke Park has been a rewarding exercise. It will not only further regional conservation efforts in the long-term, but has provided a conduit to the local community and fostered improved relations between Nanticoke GS and its neighbours. The 1998 planting was the largest such event in the Haldimand-Norfolk region. It has initiated channels of communication and possible partnerships with groups such as the Haldimand-Norfolk Rural Stewardship Network and the Haldimand Woodlot Owners group.

Future Plans

Upon completion of the 1999 planting, the area will be tended for a period of approximately 2 years using herbicide to control competition. After this, all areas may be randomly inseeded with seed material gathered from onsite natural woodlots. This would complete the "genetic" link with these areas and promote the aspect of genetic diversity. A large open area within the confines of Nanticoke Park that receives runoff and upstream drainage has proven too wet for planting and may be hydraulically modified to create a wetland. Other areas of the station property have also been identified for future habitat enhancement. The experience gathered from the Nanticoke Park naturalization will prove valuable in the initiation of these projects.

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Sensitive Indicators of Urban Stresses in Hardwood Forests along a Toronto-Peterborough Urban-Rural Corridor

Tom Hutchinson and Eric Sager

Environmental and Resource Studies
Trent University

ABSTRACT

The impact of urban and highway stresses on mature sugar maple hardwood forests are being studied at 20 sites located from downtown Toronto to NE Peterborough. We are measuring a large number of parameters to determine which ones are sensitive to urbanization stress and which are not. Amongst sensitive components are the floral diversity of the spring flora, i.e. the trillium, trout lilies, etc. which show a depauperate flora in the urban sites and those next to major highways. Similarly, the lichen flora present on the boles of sugar maples is almost absent in the urban areas while at more remote sites, a rich lichen flora exists. Nutrient cycling and restoration of decomposition processes are fundamental to successful restoration programs but urbanization seems to have a negative effect on rate of litter decomposition. Small mammal populations also seem sensitive. We will relate findings to the challenges of successful ecological restoration of terrestrial sites in urban settings, especially to restoration of nutrient cycles, biodiversity and trophic levels.

PENETANGUISHENE HARBOUR SHORE HABITAT RESTORATION & MONITORING

Stephan Crispin (presenter) **and James Dougan**

Dougan & Associates (D&A), Ecological Consulting Services, Guelph, Ontario

Cameron Portt

C. Portt & Associates, Fisheries Biologists, Guelph, Ontario

Carol Dimock and Keith Sherman

Severn Sound Remedial Action Plan (SSRAP), Midland, Ontario

ABSTRACT

The Severn Sound Remedial Action Plan (SSRAP) identified degraded fish habitat in Penetang Bay in an area with submerged wood waste from historic lumber industry activities. The adjoining shoreline park is a groundwater discharge zone which was land-filled. The Town of Penetanguishene, in partnership with SSRAP and Great Lakes Cleanup Fund, executed a plan to remove the wood and restore shoreline wetlands.

The wetland project included a public process, assessment of reference wetlands in the Bay, and detailed on-site analysis. Objectives included habitat restoration, enhanced water quality, control of Canada geese, reduced park maintenance and public education. Public participation in wetland restoration and maintenance was a priority.

In 1994, 4000 cu m of wood waste was removed and 4 ha of fish habitat restored. In 1995, two ha of shoreline parkland was excavated to create two wetlands above the high water level of the bay. Wetland seed bank was stockpiled and re-used in the restored wetlands. Fish and wildlife habitat was created incorporating spring flows, seepage zones and graded micro-channels. Upland berms were created around the wetlands. The Town and local service groups donated materials and labour for construction. Land-filled debris was removed for re-use or disposal. Naturalists and students participated in the re-planting of the site with salvaged wetland plants and seed of native shoreline species.

Young-of-the-year brook trout were identified in one of the wetlands in 1996. Ongoing habitat monitoring includes annual species checklisting, and photo-monitoring of successional growth. To date 218 plant species have been recorded; 68% of these being native.

Introduction

Penetanguishene Harbour is located on the south end of Penetang Bay in Severn Sound on Lake Huron, part of the Great Lakes ecosytem (Figure 1). Harbourfront wetlands were originally impacted by sawmill operations between 1870 and 1960, and by landfilling in the 1970's. Shoreline development around Penetang Bay resulted in additional loss of wetlands and fish habitat, and aerial surveys in the late 1980's concluded that about 68% of the historic wetlands around the Bay had been lost. This affected fisheries reliant on coastal wetlands for

spawning and nursery habitat, including northern pike and muskellenge. Algal growth resulting from nutrient enrichment was also identified as a key problem in the Bay (SSRAP 1994).

Severn Sound is one of 42 Areas of Concern on the Great Lakes identified by the International Joint Commission (IJC). The Severn Sound Remedial Action Plan (SSRAP) is a locally-based organization which was formed with federal and provincial support to co-ordinate the remediation of degraded habitats and water quality in Severn Sound. As part of broader scale documentation of problems in Severn Sound, the Interim Fish Habitat Management Plan for SSRAP identified the shoreline at the south end of Penetanguishene Harbour as a potential fish habitat restoration site. Under the co-ordination of SSRAP staff (Keith Sherman and Carol Dimock) financial and in-kind support was obtained from the Great Lakes Clean-up Fund, Town of Penetanguishene, Ontario Ministries of Natural Resources and Environment and Energy, and several community groups (Rotary Club of Penetanguishene, Le Caron and Penetanguishene Secondary Schools, Seniors for Wye Marsh, and other community volunteers) to pursue habitat restoration on this site.

In 1994, Stephan Crispin (landscape architectural intern) and Jim Dougan (ecologist) with Dougan and Associates (D&A), as well as Cameron Portt, fisheries consultant with C. Portt and Associates, were retained by SSRAP and the Town to provide expertise and design for the shore zone clean-up and shore habitat restoration project. In the following paper, the steps to complete this task are described, and available monitoring results are presented. This paper is being presented by Stephan Crispin, B.L.A., from the perspective of his role in the preliminary design studies, public consultation, detailed design and construction supervision for the habitat restoration work. The emphasis of the paper will be primarily on the design issues, construction approach, and lessons that were learned from this habitat restoration project.

1. Background

The lumber industry developed during the 1870's in Penetang Bay and remained active until the 1960's (Bayfield and Gerow 1982). Although it was evident that this industry deposited considerable wood waste in the harbour, the full extent of the deposits were not revealed until 1992 when the lake level dropped by more than a meter for several hours during a seiche event. At that point it was discovered that several hectares of the harbour were occupied by wood waste ranging in size from small lath to substantial sawlogs. This event clarified a 1989 assessment of fish habitat in the Bay which identified virtual absence of submerged aquatic vegetation in the harbour area, representing a severe limitation to the local shore fishery. Boreholes drilled through the harbour ice in the winter of 1993-94 were used to characterize the extent and depth of wood debris.

Historically, wetland cover lined the harbourfront from the Town dock around the base of the Bay, dependent on extensive groundwater seepage along the shore. In the 1970's, wetland areas which had not been destroyed by the lumber mills was buried beneath broken fill, concrete, boulders and asphalt, and converted into a manicured park by the Town. A limited amount of wetland (marsh and shrub thickets) persisted at the mouth of Copeland Creek, a coldwater stream that enters the harbour just west of the Town park, but this area has been encroached upon by marina development.

Following the landfilling and park creation, groundwater discharge created ongoing difficulties for park management and pedestrian trails. Attempts to improve drainage included the installation of weeping tiles, french drains and channels across the park; these measures were largely unsuccessful. The extent of perennial groundwater discharge was sufficient to sustain several small channels across the park and brook trout were observed in one such channel in the spring of 1995.

In addition to the wet soil conditions, the manicured turf in the park had proven increasingly attractive to Canada Geese (*Branta canadensis*). The geese congregate near the park beach, and there were concerns from park users over the presence of droppings from the geese in this area.

2. Assessment of Existing Biological Conditions

Seasonal studies of remnant wetland pockets and surveys of seepage characteristics on the park site were conducted in 1994 and 1995 by D&A. Areas of the harbour where significant woody debris had been deposited were found to be devoid of submergent vegetation, and therefore of minimal value as fish habitat. Aquatic vegetation in the surrounding areas consisted of submergent species, including tape grass (*Vallisneria americana*), water-weed (*Elodea canadensis*), and pond weed (*Potamogeton* spp.). Fish sampling carried out in 1989 by seining at a site south of the area of maximum wood waste, recorded a total of 13 fish species (Table 1). Bird use of the Harbour was previously documented by SSRAP and the Canadian Wildlife Service, and was assessed again in 1995 by personnel from the Long Point Bird Observatory (Chabot and McCracken 1997).

COMMON NAME	SCIENTIFIC NAME	COMMON NAME	SCIENTIFIC NAME
Carp	*Cyprinis carpio*	brook stickleback	*Culaea inconstans*
Blackchin shiner	*Notropis heterodon*	trout perch	*Percopsis omiscomaycus*
Sand shiner	*Notropis stramineus*	Pumpkinseed	*Lepomis gibbosus*
Bluntnose minnow	*Pimephales notatus*	Largemouth bass	*Micropterus salmoides*
White sucker	*Catostomus commersoni*	johnny darter	*Etheostoma nigrum*
Banded killifish	*Fundulus diaphanus*	yellow perch	*Perca flavescens*
3-spine stickleback	*Gasterosteus aculeatus*		

Table 1. Fish species recorded in the Penetang Harbour between July 19 and August 29, 1989 (with permission from C. Portt).

Within the Town park, typical shoreline wetland species were prevalent within the mowed turf cover. In one area of the park, mowing was abandoned as soils were too saturated to permit entry by mowers. Along the harbour shoreline, quality marsh indicator species persisted despite repeated attempts to replace them with turf cover.

3. Review of Reference Sites

In 1994 we examined six wetland areas with marsh, thicket swamp and fen cover located in other areas of Penetang Bay as potential reference systems for the habitat restoration design. Fisheries data collected by C. Portt in 1989, 1992, and 1993 was reviewed to select potential sites for typical plant communities to identify comparable habitat conditions. Based on these surveys, a shoreline fen system was identified approximately 4 km north of the harbour which exhibited a similar range of groundwater discharge, inundation characteristics and plant cover comparable to the original shoreline cover in the Harbour. Wetlands located on Copeland Creek (adjacent to the Town park) also exhibited groundwater-fed conditions and were occupied by a range of native plant communities. These habitats were dominated by tussock-forming sedges (*Carex stricta, Carex lanuginosa*), in conjunction with rushes (*Juncus spp.*), bulrush (*Scirpus americanus*), nutsedge (*Scleria verticillata*), silverweed (*Potentilla anserina*), common gerardia *(Agalinus tenuifolia*), and Ladies-tresses *(Spiranthes spp.*).

These habitats are structurally adapted to lake levels which vary on a seasonal and cyclical basis. Certain characteristics, such as the presence of substantial boulder cover within the wetlands, have helped to reduce the impact of boat wakes and associated wave action on these habitats. From the standpoint of the shore fishery, these habitats are utilized to a varying degree by northern pike (a species of concern in Severn sound) for spawning in the early spring. The amount of habitat available for spawning in particular years varies according to lake levels.

4. Wood Waste Removal

Wood waste removal was completed in September 1994 using a crane-operated grapple fork and "Visor Grab" bucket, located on a barge. This equipment loaded extracted waste onto a second barge, which was off-loaded onto dump trucks and stockpiled on an adjoining shore area for de-watering and sorting. Material was mechanically sorted; the finer material was used for compost and subsequently in wetland construction. Approximately 4000 cubic metres of waste material were removed. Extracted waste included entire sawlogs and sawdust mixed with mud. By late 1995, approximately 4 ha of in-lake fish habitat was restored as submergent aquatic plants were observed to be regenerating.

The wood waste was sorted mechanically, and most of the finer material was utilized for mulch by the Town, or reserved for use on the habitat restoration project. Coarser material was made available to the public for firewood. Some pieces of the largest logs bearing the insignia of the sawmill were salvaged and placed in the local museum.

5. Identification of Shore Habitat Opportunities and Constraints

Opportunities identified based on the site assessment and consultations with SSRAP, Town staff and the Public included the following:

- Presence of existing shoreline wetland pockets on the site, dominated by native wetland species;
- Availability of groundwater and seasonal lake fluctuations which would favour the development of self-sustaining wetland habitats ranging from submergent communities to marsh and swamp; these would restore fish and wildlife habitat which is depleted in the harbour area;
- Potential to restore culvert-lined channels across the park;
- Extracted wood waste to provide a base material for creation of new wetlands;
- Naturalization of the park to discourage loafing behaviour by Canada geese;
- Potential for re-establishment of linkages to adjoining natural habitats outside the Park;
- Community groups available for volunteer roles in wetland construction and ongoing management;
- Community partners available who may provide donations or “in kind’ services.

Certain physical, biological and logistical constraints were identified which might affect the habitat restoration works, as follows:

- Existing moisture conditions could restrict the establishment of nursery materials in restored wetlands;
- Fill containing buried rubble could produce uncertainties affecting grading, planting and drainage;
- Wave action created by large power boats could jeopardize the establishment of wetland plantings;
- Long-term lake level fluctuations (+/- 1.6 m) could create future erosion problems along the shoreline;
- Removal of the wood waste in the harbour before shore habitat restoration could begin.

6. Consideration of Alternative Habitat Restoration Approaches

Four options were initially presented to the Town Council by SSRAP and the consultants, as follows:

A. Remove wood waste only (no shore habitat restoration);
B. Allow portions of the park to naturalize by reducing mowing in the wettest areas;
C. Excavate wetlands within a limited area behind the present shoreline;
D. Excavate wetlands and restore associated natural habitats across the entire waterfront park.

Following a review of the potential constraints and likely public concerns associated with each option, Option C was selected for the development of a Concept Plan.

7. Concept Plan

A Concept Plan (Figure 2) for a linked series of wetlands totalling 2 ha in area, and naturalization of adjoining creeks were prepared by S. Crispin of D&A. Gentle side slopes, berms, soil wedges and rocks were integrated to provide diverse micro-habitats for fish, bird and amphibian species. Existing park trails were connected across the wetlands with small bridges.

Key objectives of the design included the following:

(1) Concentration of groundwater flows to provide baseflow channels for potential fish migration.
(2) Wetland grading to permit periodic inundation in high lake level periods.
(3) Armouring and grading of the wetland entrance to minimize erosion potential.
(4) Nodal plantings of showy native plants to provide immediate aesthetic effects.
(5) Re-naturalization of existing channels through the park.
(6) Planting design utilizing native species to enhance wildlife habitat while maintaining key harbour views.
(7) Re-grading to create islands of better-drained soil that would support upland trees, shrubs and groundcovers.
(8) Re-use of site materials including wetland soil seed bank, wood waste, clean fill materials (i.e. rock, sand).
(9) Reduced maintenance requirements within the park, reflected in a detailed management plan.
(10) Pedestrian access to the shoreline and wetland, and interpretive opportunities (i.e. signs).
(11) Enhanced quality of park runoff entering the Harbour.
(12) Reduced 'loafing' opportunities for Canada geese.
(13) Opportunities for public participation in the planting and on-going maintenance of the wetland.

8. Public Participation

Public process played a critical role in this project, from the development of design strategies and Concept Plan to actual construction of the wetlands. Several forums for public consultation and education with Town and SSRAP staff were carried out in the autumn of 1994 and early 1995 including a day-long workshop, a public meeting and several Town Council meetings. In order to communicate the future appearance of the habitat restoration to the public, a photo-realistic visual simulation of an aerial view of the proposed wetland restoration was prepared using Adobe Photoshop™ (Ver. 3.0) software on an Apple MacIntosh™ computer. This was compared to an actual photo of the existing waterfront park site.

Issues related to the habitat restoration were identified at this workshop by the public, Town staff, Council and SSRAP. These included:

(1) The desire on the part of local naturalists to maximize linkage of restored habitats to existing habitats located outside the park boundaries.
(2) Concerns that views from existing residences facing the Bay would eventually be obstructed by trees.
(3) The prominent location of the site, requiring consideration of aesthetics, safety, nuisance factors (e.g. mosquitoes, Canada geese) and security;
(4) The need to take the multiple recreational uses of the park into account;
(5) The possibility of infestation by purple loosestrife (*Lythrum salicaria*) or other invasive exotic plant species
(6) The need to monitor the results of the proposed habitat restoration;
(7) The rationale for re-establishing wetland cover in a high-profile location within the park as opposed to a peripheral area adjacent to the Copeland Creek Wetland; and
(8) The elimination of approximately 2 hectares of turf area within the 30 hectare park.

9. Detailed Design

Following intensive public consultation, the project proceeded to detailed design. This required finalization of the habitat design, and detailed estimation of materials, equipment and budget required to complete the project. It was recognized that given uncertainties associated with the landfilled materials and groundwater patterns, flexibility would be required during construction. The SSRAP was closely involved in negotiations with potential partners and sources of 'in-kind' materials and labour. This was required to obtain matching financial support from the Cleanup Fund. Ultimately, the main cost associated with construction was for the hiring of an excavation contractor, and construction supervision. Most of the other labour and equipment was provided by the Town or volunteers.

As part of the detailed design, a landscape management plan was devised which specified required maintenance in the restored habitat area. This was a key concern of Town staff who would be involved in the future maintenance of the area. Three Management Zones were identified including Manicured Turf, Wildflower Meadow with Tree and Shrub Plantings, and Wet Meadow / Seepage Zones (Figure 2). The intent within these zones was to a) provide safety and comfort for trail users, b) identify well defined limits to the maintained areas, and c) minimize maintenance requirements within the natural habitat areas, other than occasional litter collection.

10. Wetland Construction

In 1995, 2 ha of shoreline parkland was excavated to create 2 wetlands located above the high water level of the Bay. Wetland construction was initiated in August and completed by mid-September. The habitat creation works were conducted under the supervision of S. Crispin in close consultation with SSRAP and Town staff. A sediment control plan was implemented, utilizing silt curtains, straw bale barriers and a sediment pond to minimize contamination of the Harbour. Topsoil was stripped and stored on site and a substantial amount of on-site wetland seed bank was salvaged for re-use in the created habitats. Buried materials, such as concrete, which were not suitable for berm creation were removed from the site for re-use as fill on other sites, or for deposition in a local landfill.

Substantial surges of groundwater were encountered during excavation that required several days to dissipate. Water from the excavations was pumped into the on-site sediment basin. Deposits of sawdust and wood waste created difficulties in excavation of footings for the pedestrian bridge. During excavation of the easterly wetland, organic soils were encountered which originated from the wetlands buried in the 1960's. The concrete foundation of one of the original sawmills was encountered, and left in place as a cultural heritage element.

The primary soil material in the excavation consisted of dry sterile sands. These were used to create berms around the perimeter of the created wetlands, in order to provide more sheltered habitat and to direct runoff from the surrounding area of the park.

Once the main area of the wetland was excavated and drained, fine grading of channels and pools was undertaken based on the locations of major springs in the excavated area. This required some modification of the original design. Boulders encountered during excavation were incorporated into the wetlands as aesthetic accents and perches for waterbirds.

An adjoining channel was naturalized and reverted to a natural channel form by removing existing metal culverts, and minor re-grading of bank areas. Due to the presence of sands and coarser materials in the bed area, the flows were allowed to adjust the stream channel without additional grading. Subsequent to completion of this project, other channels in the park have also been naturalized.

After fine grading, stockpiled wetland seed bank materials were re-applied to the re-graded site. Upland meadow areas were seeded with a low-maintenance grass-legume blend, supplemented with pockets of native shoreline meadow species. A blend of native wetland species was seeded into nodal locations within the wetland. Local volunteers participated in the initial plantings of the site, utilizing salvaged wetland and upland trees, shrubs and herbaceous plants.

The collaborative nature of this project was evident throughout the construction of the wetlands. Wetland grading was completed by a local contractor assisted by Town equipment and personnel. Donated labour and materials from the Town, local service groups and the Ontario Ministry of Natural Resources' Community Wildlife Involvement Program were used to complete the trails and bridge, while many of the plantings were conducted by local volunteers from naturalist clubs, secondary schools and seniors groups.

11. Monitoring Plan

A Monitoring Plan was developed by D&A and C. Portt for the shoreline habitat restoration. It focused on monitoring changes in plant communities and their diversity over time, utilization by fish and wildlife species, and effectiveness of pedestrian access and interpretive programs. The plan was designed to encourage ongoing monitoring by naturalists and other volunteers, and contained monitoring protocols for fisheries, vegetation, wildlife, hydrology and site infrastructure (recreation, interpretive facilities).

Vegetation monitoring was designed to monitor initial establishment success (species and cover), document successional progress over time, and monitor species composition and habitat complexity. The monitoring approach included the preparation of species checklists for the two wetlands, and photo-monitoring with a standardized 2.5 m tall colour board divided into 0.25 m black and white segments. This was placed at fixed locations around each habitat area. The photo-monitoring method was adapted from an approach described by Van Horn & Van Horn (1996), and is particularly well adapted to recording changes in herbaceous and shrub communities, allowing compilation of quantitative data on vegetation density, height and water depth. It is also useful in the context of the Pentanguishene site as it can document wetland impacts on human views, maintenance issues, and other details.

With respect to fisheries, utilization of the wetland streams by fish species, and changes in substrate, cover and flow were considered monitoring priorities. Wildlife monitoring, specifically of marsh birds and amphibians, was included in the plan. While no wildlife monitoring was conducted under the 1996 program, in 1997 staff from the Long Point Bird Observatory undertook assessments of bird and amphibian communities for locales throughout the Severn Sound area including the Penetang Bay site, but has yet to publish this data. Monitoring is in accordance with the Marsh Monitoring Program developed by Environment Canada (see Chabot and McCracken 1997).

Recording recreational, interpretive and infrastructure use was also recommended using field checklists in the vicinity of the restored wetlands twice per year. The plan also recommended the photo-monitoring as a useful cross-reference of human impacts in the wetlands, and development of a Park User Survey to summarize user information and identify potential improvements to access or interpretative facilities. Monitoring of the stability and performance of the channels connecting the wetlands to the lake was recommended on an annual basis.

Monitoring was conducted for fisheries in 1996 and vegetation in 1996 and 1997 by the consultants authoring this paper. Vegetation monitoring included preparation of checklists of plant species in evidence in Wetlands 1 and 2, descriptions of the distinct habitat types (Table 2), and provision of photographic documentation (as

described above). In 1997, 218 vascular plant species were recorded in the restored habitat, of which 149 (68%) were native species. Many of the introduced species recorded are annuals and biennials associated with primary succession on the site, particularly on the dry sandy berms.

During fisheries monitoring by C. Portt in 1996, no fish were captured in Wetland 1 or the existing stream located west of Wetland 2. However, in Wetland 2, 2 brook trout (*Salvelinus fontinalis*) and 1 sculpin (*Cottus spp.*) were captured near the mouth of the stream draining from the wetland. The presence of young-of-the-year brook trout in August 1996 is particularly encouraging as this species is an important game fish reliant on coldwater conditions and adequate substrates.

Some problems were noted during these monitoring efforts. In 1996, seedlings and shoots were heavily grazed by Canada geese, and seedlings of two weedy shrub species (Manitoba maple and glossy buckthorn) which could affect future wetland character were identified. In addition, rip rap accumulation at the mouth of both wetlands was identified as a potential barrier to fish movement.

Management measures to resolve these problems involved hand-pulling of these readily identifiable weeds by volunteers in 1997 and 1998, and redistribution of the rip rap in the shallow zones, also by volunteers. In 1997, the lake level was higher than normal, and there were no obstructions in the wetland channels and by this time vegetation was sufficiently tall to discourage further foraging by geese.

Habitat Type	**Description**
Successional Dry Meadow	Located on barren sands associated with constructed berms. This area was seeded with shoreline grass-wildflower blend in late 1995. Cover was sparse in 1996, but increased after autumn rains in 1996. Prevalent Species: Wild Carrot (*Daucus carota*), Horseweed (*Conyza canadensis*), Oxeye daisy (*Chrysanthemum leucanthemum*), Evening primrose (*Oenothera biennis*), Bracken Fern (*Pteridium aquilinum*), Brown-eyed Susan (*Rudbeckia hirta)* Quality Indicators: Little Bluestem Grass (*Schizachyrium scoparium*), Goldenrods (*Solidago spp.*), Arrow-leaved Aster (*Aster urophyllus*), Butterfly Weed (*Asclepias tuberosa*)
Wet Meadow/Marsh	Located in wet interior areas of Wetlands 1 and 2 as well as along the banks in the lower reaches of each stream. It originated mostly from salvaged seed bank material (sods) from the original wetlands on site, supplemented with salvaged plants from other locations. Prevalent Species: Common Cattail (*Typha latifolia*), Sedges (*Carex* spp), Rushes (*Juncus* spp), Spike Rushes (*Eleocharis erythropoda and E. smallii*), Canada Bluejoint Grass (*Calamagrostis canadensis*), Tussock Sedge (*Carex stricta*), American Bulrush (*Scirpus pungens*), Softstem Bulrush (*Scirpus validus*), Joe Pye *Weed (Eupatorium maculatum*), Bur-reeds (*Sparganium eurycarpum & S. chlorocarpum*), Swamp Milkweed (*Asclepias incarnata*), Barnyard Grass (*Echinocloa crusgallii*), Spotted Touch-me-not (*Impatiens capensis*), Sensitive Fern (*Onoclea sensibilis*), Blue Flag Iris (*Iris versicolor*) Quality Indicators: Royal Fern (*Osmunda regalis*), Common Gerardia (*Agalinus tenuifolia*), Fringed Gentian (*Gentianopsis crinita*), Grass-of-Parnassus (*Parnassia glauca*), Northern Manna Grass (*Glyceria borealis*)

Submergent/Floating Aquatics	This habitat has flourished along the spring-fed channels within the wetlands, and covered the water surface completely in several locations. The plant material originated primarily from seed bank sources. Prevalent Species: Watercress (*Nasturtium officionale*), Swamp Buttercup (*Ranunclus hispidus*) Quality Indicators: Water-plantain (*Alisma plantago-aquatica*), American Pennyroyal (*Veronica americana*)
Shoreline Wet Meadow	This habitat was prevalent along the unmanaged shoreline prior to wetland construction, and is now re-establishing wherever it was disturbed, from seed and root material. Prevalent Species: American Bulrush (*Scirpus pungens*), Silverweed (*Potentilla anserina*), Canada Blue-joint Grass (*Calamagrostis canadensis*), Creeping Bent Grass (*Agrostis stolonifera*), Purple Loosestrife (*Lythrum salicaria*) Quality Indicators: American Bulrush (*Scirpus pungens*), Canada Blue-joint Grass (*Calamagrostis canadensis*)

Table 2. Summary descriptions of restored shoreline habitats.

Summary & Conclusions

The habitat restoration project described in this paper represented a significant undertaking for the Town of Penetanguishene and SSRAP. From the Town's perspective, it reflected a growing awareness of the key role of communities in the restoration of degraded habitat areas around the Great Lakes basin. Given that the Town had devoted twenty years to the creation of a manicured waterfront park, its partial re-conversion to natural habitat was an important step in increased local awareness. Although the more aggressive option of restoring connections to nearby habitats was not accomplished, this represents a future opportunity. As consultants on this project, we were witnesses to changes in public attitudes on a day-to-day basis, as we saw opponents of the habitat creation become its stewards.

The strategies and methods employed for the wood waste removal and habitat creation, were largely successful in re-utilizing site materials including the existing soil seed bank. These methods, supplemented by imports of seed and salvaged plants, have resulted in a high level of diversity for a small natural area surrounded by urban space.

The fisheries and vegetation monitoring indicate that the restored habitats are already sustaining a significant component of native, quality species since construction was completed in 1995. With respect to fisheries, the two species recorded are positive indicators and additional utilization by fish is anticipated as vegetative cover proliferates and provides shading and more diversified structure.

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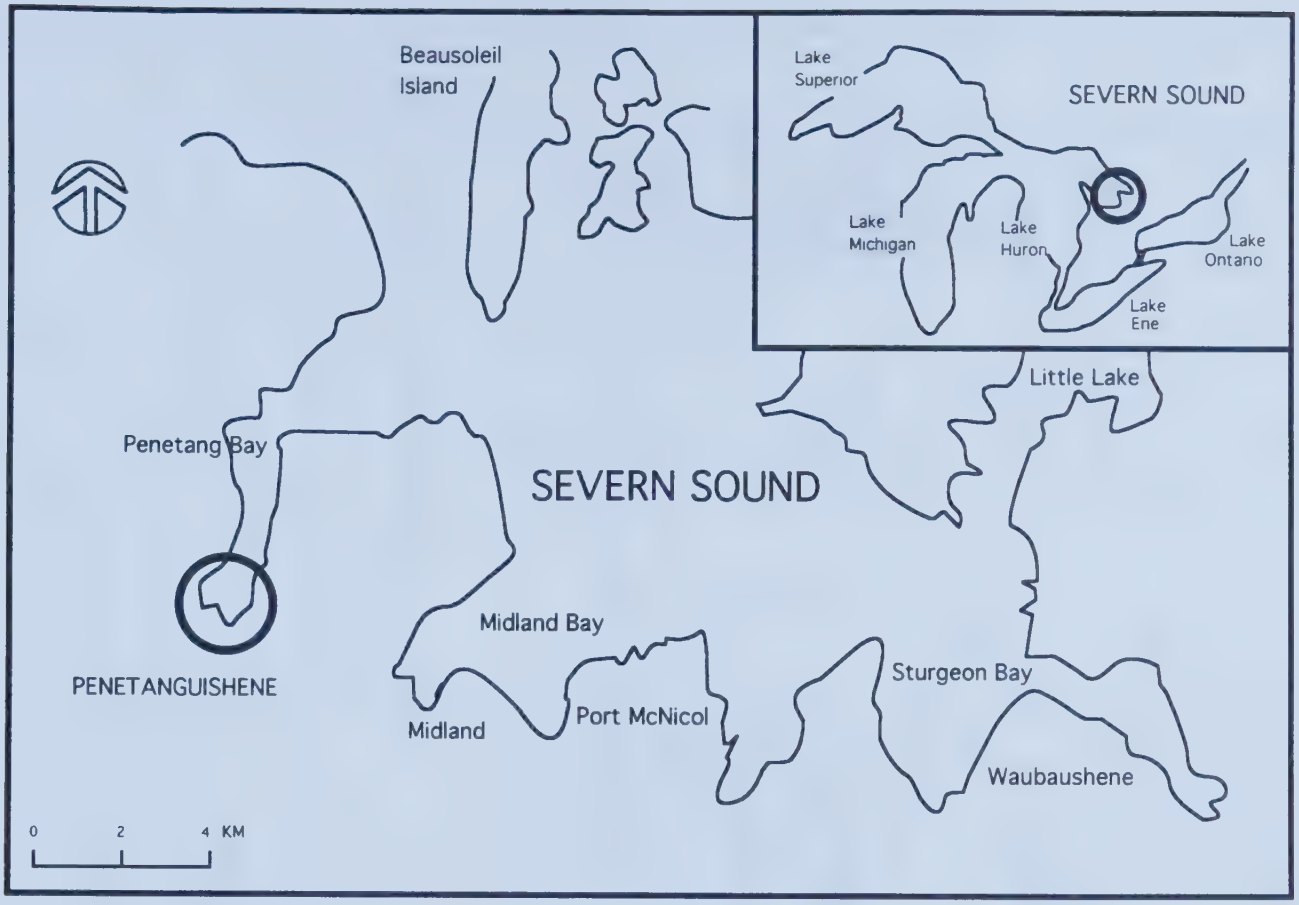


Figure 1 Penetanguishene Harbour Site Location

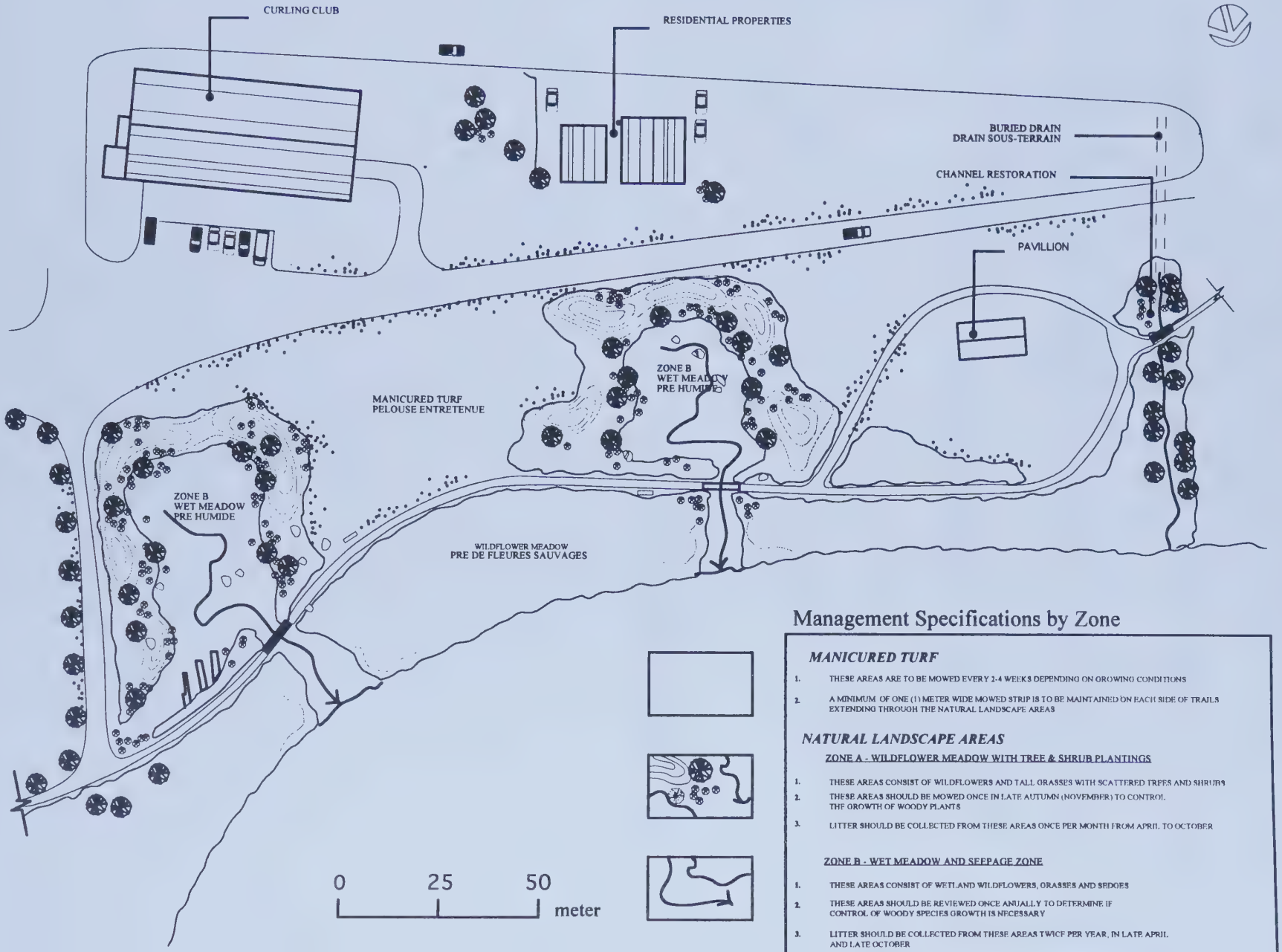


Figure 2. Concept Plan and Management Zones

THE INFLUENCE OF CYANOBACTERIAL AMENDMENTS ON SOIL AGGREGATE SIZE, SOIL NITROGEN CONTENT AND SEEDLING ESTABLISHMENT IN A GRAVEL PIT

Donna Casper, Christine D. Maxwell, and Mark Browning*

Biology Department
Trent University
Peterborough, Ontario

*Science Development and Transfer Branch
Ministry of Natural Resources,
Peterborough, Ontario

ABSTRACT

Cyanobacteria are amongst the first colonizers of disturbed lands and their activities are reported to improve soil conditions by the addition of fixed atmospheric nitrogen, by aggregation of soil particles, and by the enhancement of seed germination and establishment. Seedling establishment may also be improved by the presence of soil crust disturbances such as cracks and irregularities in the microtopography. In this study, we report the results of experiments in a field situation and in controlled greenhouse conditions in which a bulk culture of the nitrogen-fixing cyanobacterium, *Nostoc commune*, was sprayed onto the soil surface. Three replicates of four treatments were used: soil surface inoculated with *Nostoc* and surface disturbed by trampling, soil surface inoculated and surface undisturbed, soil surface not inoculated and disturbed, and soil surface not inoculated and undisturbed.

After a period to allow for growth of *Nostoc*, seeds of *Poa compressa,* Canada bluegrass, (field study) and *Schizachyrium scoparium* Little bluestem, (greenhouse study) were sown on all surfaces. Results from the field and greenhouse studies differed greatly. Soil aggregate size and nitrogen content were not significantly different among treatment groups in the field plots, however, in the greenhouse significantly larger aggregates were produced in inoculated trays, and a significant interaction was found among all treatments for the NH_4^+ form of soil nitrogen. In the field, disturbance enhanced seedling emergence and early establishment significantly, though this effect was not evident in the greenhouse trials.

Introduction

Human dependency on sand, gravel and crushed stone resources requires the removal of surface soil and vegetation over large expanses of land at licensed extraction sites. In Ontario, the 1990 Aggregate Act was established to ensure that members of the aggregate industry have an acceptable plan for the restoration of the extracted area prior to breaking ground. Restoration plans typically include alteration of the physical topography after the completion of extraction and the re-establishment of vegetation to prevent soil losses by erosive forces. Frequently aggregate companies select non-native rapidly germinating ground cover species that require high initial maintenance, including fertilizer and topsoil, and which can slow natural succession for many years.

It may be possible to achieve faster rates of native seedling and plant community establishment by utilizing pioneer colonizers of disturbed lands. Pioneer colonizers condition the soil and prepare it for vascular plant colonization. Algae and cyanobacteria are known to fulfill this role in arid and semi-arid environments where they are integral components in structures known as cryptogamic crusts (Campbell *et al.* 1989; Ashley and Rushforth 1984). Many of the properties commonly associated with cryptogamic crusts may be attributed to the algal/cyanobacterial

component, even though lichens, mosses, fungi and bacteria are often present..

Beneficial properties typically associated with cryptogamic crusts include: reduction of aeolian and water erosion (McKenna-Neuman *et al.* 1996; Maxwell and McKenna-Neuman 1994; Campbell *et al.* 1989; Forster and Nicholson 1981), increased size of soil aggregates, increased water infiltration and retention rates, and increased organic and inorganic nutrient content of the surrounding soil (Johansen 1993; St. Clair *et al.* 1984; Booth 1941). These factors result in improved conditions for seedling germination and establishment (Johansen 1993; St. Clair *et al* 1984; Booth 1941). In addition, St. Clair *et al* (1984) report enhanced seedling germination on intact crust surfaces compared to surfaces damaged by simulated trampling, indicating that surface microtopography may be an important factor.

Cyanobacteria are prime candidates for use in restoration practices due to the beneficial properties associated with cryptogamic crusts. The innoculant used in this study was *Nostoc commune* Vaucher, a heterocystous nitrogen-fixing cyanobacterium commonly found in cryptogamic crusts throughout the world. The purpose of the study was threefold: 1) to determine the effect of *Nostoc commune* on soil aggregation and soil nitrogen content; 2) to determine whether crust formation enhanced seedling germination and establishment; and 3) to examine the influence of crust disturbance on seedling establishment.

Crust and Seedling Establishment in a Field Situation

Site Description

Pinewood Aggregates Site: 44°18.1′ north; 78° 4.1' west

The field location used in this study, Pinewood Aggregates, is located approximately 23 km east of Peterborough, Ontario. This site is an active sand and gravel pit. A section of the pit, which had not been extracted for approximately three years, was designated as the study area by Pinewood Aggregates management. At the time of this study, there had been no restoration activity in the study area, as it is the intention of the company to use the area in future extraction operations. As a result, very little vegetation was present in the area prior to the initiation of this study; however, all quadrats were cleared of existing vegetation by hand before treatments began.

Twelve quadrats (1m x 1m) were set up using 17m by 17m gridlines along the north-south and east-west axes of the allotted study area. The topography of the site was level. Plots were randomly chosen by means of a Random Number Table. Treatments were randomly assigned. The 12 study plots were separated into 4 treatments groups: not inoculated/undisturbed; not inoculated/disturbed; inoculated/undisturbed; and inoculated/disturbed.

The cyanobacterial amendment used to inoculate the plots consisted of a solution of 2.8 L of *Nostoc commune* (University of Toronto Culture Collection, UTCC 314) cultured in Bold Basal Medium (Nichols and Bold 1965) and 8.9L of de-ionized water. Prior to spraying, *Nostoc* masses were blended in a glass blender for approximately 1 minute to allow for easy passage through the nozzle of the spray applicator.

Two litres of cyanobacterial cutlure were applied to each of the six experimental plots on June 10, 1996. Uninoculated plots were watered with two litres of deionized water. All test plots were watered on a daily basis with 2L of tap water, except on days when a significant rainfall occurred, but the amount was reduced to 1L between July 02 and August 13. To further encourage crust development, 0.25L of Bold Basal Medium was applied to each test plot on three occasions, and clear plastic sheets were placed over each plot to reduce excessive evaporation.

Soil sampling was conducted randomly on June 10 and August 13 by taking 3 sub-samples from each plot. Plots designated as "disturbed" were trampled by two individuals, each of whom took 25 evenly distributed steps per plot. Following disturbance treatments, seed were dispersed to all plots by hand. Each plot was seeded with 2g of

Poa compressa seeds by hand. This amount is based on the standard seeding rate of 20kg/ha per species recognized by most aggregate companies. Each plot was given 1 L of tap water following seeding, after which all watering activities were terminated.

Seedling emergence and establishment were assessed by counting the total number of seedlings present in each plot on October 25.

Seedling Establishment under Greenhouse Conditions

A similar study was conducted in greenhouse conditions. Sand was collected from the Pinewood Aggregates field site, and autoclaved at 120 C for 20 minutes to remove any existing biota. It was then divided between twelve plastic-lined aluminum trays (29.9cm x 23.5cm x 6.4cm). Three replicates of each treatment were assigned randomly to the trays. The treatment groups were the same as for the field component.

550ml of a bulk culture of *Nostoc commune* was sprayed onto each of the test trays, while uninoculated trays were watered with an equivalent amount of deionized water. Trays were watered on a demand basis (approximately every 2 to 3 days) with 0.25L of water per tray, however, all trays were given the same amount of water on the same day to retain a consistent watering level. Although a surface growth was visible at the beginning of the experiment, it soon vanished and no signs of growth were visible for the following 2 months.

Some problems were experienced with both crust dessication and contamination. At this time a tent, constructed of clear plastic sheeting, was placed over the experimental trays in an effort to reduce contamination and to maintain adequate temperature and moisture levels for cyanobacterial growth.

On February 24 all trays assigned to disturbance treatment were subjected to 25 blows to the soil surface with an Erlenmeyer flask. This action was used to simulate trampling. Following disturbance, 0.141 g of *Schizachyrium scoparium* (Little Bluestem) seeds were distributed by hand to each tray. The seeding rate used is based on the same 20 kg/ha standard seeding rate applied to the field study. Trays were watered every 2 days with 150 ml. of de-ionized water until March 08. After which the amount of water was increased to 200 ml. per tray. In addition to watering, trays were moved every 2 days to avoid a position effect. Watering rates were increased to daily on March 22, and each tray was given 150 ml. of de-ionized water on a daily basis until April 07.

Seedling emergence data was statistically analyzed with a 3-way ANOVA (Zar 1996).

Soil Nitrogen Content

Soil samples from both the field and the greenhouse were analyzed for soil nitrogen content in the bio-available forms of NO_3^{2-} and NH_4^+. For each study site the initial soil nitrogen content was compared to the soil nitrogen content after cultivation of a cyanobacterial crust. Soil extractions were completed with 2M KCL solution according to the methods of Kalra and Maynard (1991). Soil extractions were filtered with a vacuum filtrator. Levels of NO_3^{2-} and NH_4^+ were measured on a Technicon Autoanalyzer II. Soil nitrogen results were analyzed with a 3-way ANOVA (Zar 1996).

Soil Aggregation

Soil samples stored at 5°C prior to sieving. Several days prior to testing soil samples were dried on U-cut paper bags. Soil aggregate size was examined on the Wentworth scale with sieve trays ranging from -2.0 to +3.0 phi units. Each sieve tray was shaken 50 times by hand. The mean particle size for each plot was analyzed by a 3-way ANOVA (Zar 1996).

Results

Soil Nitrogen Content

ANOVA results for the Westwood field site indicate that there is no significant difference among any of the treatment groups in soil nitrogen content in the forms of NH_4^+ and NO_3^- (see table 1). In addition, no significant interactions were found among any of the groups. Soil nitrogen results from greenhouse soil samples indicate that inoculated trays had significantly higher levels of NH_4^+ ($F=32.35$; $p<0.001$). There were also significant interactions among all factors for NH_4^+ ($F=7.93$; $p<.01$).

Table 1 Soil nitrogen and ammonium content

Treatment	Pinewood field site					
	Start (10-06-96) NO_3 ± s.d. (mg/g) (n = 3)	Finish (13-08-96) NO_3 ± s.d. (mg/g) (n = 3)	Difference ± s.d.	Start (10-06-96) NH_4 ± s.d. (mg/g) (n = 3)	Finish (13-08-96) NH_4 ± s.d. (mg/g) (n = 3)	Difference ± s.d.
Control / undisturbed	1.02 ± 0.92	3.97 ± 5.27	-2.95 ± 4.36	1.54 ± 0.95	0.39 ± 0.29	1.15 ± 1.08
Control / disturbed	0.49 ± 0.15	2.06 ± 0.95	-1.57 ± 0.98	0.86 ± 0.66	0.75 ± 0.27	0.11 ± 0.52
Nostoc / undisturbed	0.50 ± 0.21	1.19 ± 1.43	-0.70 ± 1.63	1.27 ± 0.96	1.36 ± 0.41	-0.09 ± 0.97
Nostoc / disturbed	0.55 ± 0.37	1.16 ± 0.94	-0.61 ± 0.71	1.21 ± 0.81	0.37 ± 0.29	0.84 ± 1.09
	Greenhouse					
	Start (04-10-96) NO_3 ± s.d. (mg/g) (n = 3)	Finish (04-04-97) NO_3 ± s.d. (mg/g) (n = 3)	Difference ± s.d.	Start (04-10-96) NH_4 ± s.d. (mg/g) (n = 3)	Finish (04-04-97) NH_4 ± s.d. (mg/g) (n = 3)	Difference ± s.d.
Control / undisturbed	0.68 ± 0.80	0.44 ± 0.01	0.24 ± 0.01	0.59 ± 0.83	0.1 ± 0.01	-0.48 ± 0.01
Control / disturbed		0.44 ± 0.07	-0.24 ± 0.07		1.15 ± 1.43	0.57 ± 1.42
Nostoc / undisturbed		1.20 ± 1.20	0.52 ± 1.19		2.23 ± 1.24	1.64 ± 1.24
Nostoc / disturbed		0.54 ± 0.08	-0.14 ± 0.08		1.83 ± 1.17	1.24 ± 1.17

Soil Aggregation

ANOVA results of soil aggregation data from the field site at Pinewood Aggregates indicate that there is no significant difference among any of the treatment groups in the size of soil aggregates (see table 2). In contrast, results from the greenhouse soil samples indicate that inoculated trays contain significantly larger aggregates than control trays ($F=8.90$; $p<0.01$) (see table 2). The mean aggregate size of inoculated trays was 0.877 phi, while the mean aggregate size of control trays was only 0.640 phi. No significant differences were found for before/after inoculation and disturbed/undisturbed trays for the greenhouse soil samples.

Table 2 **Soil aggregation**

Treatment	Pinewood field site		Greenhouse	
	Start (13-06-96) ($\phi \pm$ s.d.) (n = 3)	Finish (14-08-96) $\phi \pm$ s.d.) (n = 3)	Start* ($\phi \pm$ s.d.) (n = 3)	Finish ($\phi \pm$ s.d.) (n = 3)
Control /undisturbed	0.49 ± 0.14	0.23 ± 0.20	0.98 ± 0.16	1.29 ± 0.38
Control / disturbed	0.72 ± 0.05	0.51 ± 0.82		1.29 ± 0.65
Nostoc / undisturbed	0.70 ± 0.32	0.74 ± 0.34		0.75 ± 0.01
Nostoc / disturbed	0.64 ± 0.28	0.62 ± 0.45		0.80 ± 0.60

Seedling Emergence and Early Seedling Establishment

ANOVA results of seedling counts from Pinewood Aggregate plots indicate that disturbance is the most important factor out of the treatments tested in promoting seedling germination and establishment ($F=13.050$; $p<0.01$) (see table 3). The mean number of seedling from disturbed plots was 485, whereas the mean number of seedlings from undisturbed plots was 137. Inoculation did not have a significant effect on seedling emergence and seedling establishment at the Pinewood Aggregates field site.

ANOVA results of greenhouse plots indicate that inoculation is the only significant treatment ($F=6.84$; $p<0.03$). The mean number of seedlings in inoculated trays was 8.5, compared to 2.5 mean seedlings in control trays.

Table 3 **Seedling emergence**

Treatment	Pinewood field site Seedling no. ± s.d.	Greenhouse Seedling no. ± s.d.
Control / undisturbed	204 ± 185	1 ± 1
Control / disturbed	421 ± 124	4 ± 2
Nostoc / undisturbed	70 ± 15	11 ± 6
Nostoc / disturbed	449 ± 70	9 ± 5

Discussion:

Soil Nitrogen Content

Soil nitrogen results for the Pinewood Aggregates field site and for the greenhouse differed greatly. At the field site there was no significant difference in the soil content of NH_4^+ or NO_3^{2-} among any of the treatment groups. Results from the greenhouse study indicate a significant interaction among the treatment groups. Several factors may explain the discrepancy in the results. Possibly the greatest difference between the sites is that the soil in the greenhouse was autoclaved prior to usage to remove all existing soil biota. Soil at the Pinewood field site contained viable algal and cyanobacterial communities, which during the cultivation period formed an endemic crust. Samples of the endemic crust were taken, cultured in Bold Basal medium, and algal and cyanobacterial components were identified to the genus level. The endemic crust consisted of: cyanobacteria *Lyngbya, Nostoc,* and *Chroococcus,* the chlorophytes *Ulothrix* and *Stichococcus*, and a euglenoid.

The endemic crust was found in all but one of the quadrats at Pinewood. It seems likely that the lack of difference among the treatment groups resulted from the presence of an endemic crust. All but one of the plots contained nitrogen-fixing cyanobacteria. It is possible that all but one of the plots were experiencing higher soil nitrogen levels compared to soil that does not contain any cyanobacterial amendments, however, there may not have been a significant difference in the levels of soil nitrogen between the plots.

In the greenhouse, the difference in soil nitrogen was seen in a significant interaction among all the treatment groups for NH_4^+. It is likely that the difference was only seen in NH_4^+. and not NO_3^{2+} because NO_3^2 is a more mobile form of nitrogen. When nitrogen is present in the soil as NO_3^2 it tends to volatize or is leached or taken up rapidly by plants thus it may not be a good indicator of soil nitrogen content (Hausenbuiller 1985).

Soil Aggregation

Results of soil aggregation tests on Pinewood field site soil samples indicate that there is no significant difference in aggregate size among the treatment plots. It is likely that this is result of the endemic crust as well. The endemic crust contained several mucilaginous and filamentous algal and cyanobacterial genera. The same binding properties associated with *Nostoc* are also observed in other genera. Soil aggregation by cyanobacteria and/or algae is thought to be both mechanical and chemical in origin. Mechanical aggregation results from filamentous algal and cyanobacterial forms grasping and attaching onto soil particles (Campbell *et al.* 1989; Forster and Nicholson 1981, Fletcher and Martin 1948). Chemically, soil aggregation is strengthened by the excretions of polysaccharides and polypeptides (Isichei 1991), and by sheath production in filamentous cyanobacteria which when wet acts as a gluing agent (Campbell *et al.* 1989; Campbell 1979). Since both the endemic crust and the cyanobacterial amendment contained genera that exhibit binding properties, the lack of difference in soil aggregate size is not surprising.

The results of the analysis of soil aggregate size from the greenhouse indicate that trays which have been inoculated with the cyanobacterial amendment contain significantly larger soil aggregates than plots which have not been inoculated. The larger soil aggregate size is likely a direct result of the *Nostoc* mechanically and chemically binding the soil particles. The disparity between the greenhouse and field results can be attributed to the lack of crust forming organisms in uninoculated greenhouse trays..

Seedling Emergence and Early Establishment

Significant differences in seedling emergence and early seedling establishment were observed in both the greenhouse and the Pinewood field site, however, the treatment plots in which the differences were observed differed between the field and the greenhouse. In the field, significantly greater seedling emergence and early establishment were observed in plots subjected to disturbance treatment. Since almost all the plots at the field site contained some form of crust, this result is not surprising. Johansen (1993) suggested that crust surface microtopography may be an important factor in seedling establishment. In this study, the crust surfaces were relatively smooth compared to the pinnacled crusts described by Johansen (1993). It seems likely that the sown seeds risk being blown off such surfaces or be subject to predation. Cracks in the surface produced as a result of disturbance may provide more suitable "safe sites" for germination and establishment, with increased nutrient content, increased water availability and soil stability.

In the greenhouse, inoculated trays had significantly greater seedling emergence and seedling establishment. Trays which received no cyanobacterial amendments in the greenhouse were also devoid of all cryptograms due to autoclaving the soil prior to other treatments. Therefore, the results from the greenhouse confirm that the presence of a cyanobacterial crust can enhance seedling emergence and seedling establishment. Greenhouse samples were only tapped on the surface 25 times with the side of an Erlenmeyer flask; this may not be comparable to trampling by two individuals.

Conclusions

This study provides some preliminary evidence that the application of cyanobacterial amendments to gravel pit soil surfaces may aid in restoration practices, although further testing is necessary on a larger scale to determine the degree. Results from the field site did not reveal a significant beneficial effect of cyanobacterial amendments, however, the interference of an endemic crust may be masking the true differences. Promising results were found in the greenhouse where soil aggregates were found to be significantly larger, levels of soil nitrogen in the form of NH_4^+ were higher, and seedling emergence and early establishment was better on soils treated with a cyanobacterial amendment. Field results indicate that disturbance may have an important influential role, and hints that perhaps another avenue to examine is the utilization of endemic crusts in restoration practices.

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HISTORICAL LAND USE INVENTORIES: A GUIDE TO THEIR CREATION

Scott M. MacRitchie

MacDiamond Environmental Services

David A. Block

Masters Program
Faculty of Environmental Studies
York University

ABSTRACT

Many Ontario municipalities contain formerly industrial and commercial land (brownfields) which is now available of re-use as parkland, residential, green industrial and other land uses. Developing municipal historical land use inventories for identifying potentially contaminated sites is a first step in the safe redevelopment of this land. The Canadian Urban Institute and the Environmental Protection Office, City of Toronto, developed a guidebook for municipalities which want to create their own inventories of historical land use.

The guide defines a step-by-step process that begins with defining the scope of the inventory, then provides options for inventory design and format, identifies historical and environmental sources of information, and the need for maintenance and defining municipal liability. An example of simple inventory that illustrates the various sources of information in provided in an appendix.

An inventory of historical land uses can be a first step to more comprehensive environmental inventories that will provide information vital to the ecosystem approach and to planning for sustainability. Knowledge of the past is essential to building safe and enduring communities for the future

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Introduction

When addressing issues of intensification, the Canadian Urban Institute investigated the topic of potentially contaminated sites and found that few municipalities had identified such sites. It was learned that no generic methodology for establishing and maintaining inventories of potentially contaminated sites existed. The concern was that municipalities should be planning for intensification through redevelopment of these sites, yet had no indication of where contaminated sites may be located and no tool to help them, except on a site-by-site basis. It was also learned that the Ontario Ministry of Health was working on directives to local boards of health requiring the identification of public health risks, which included contaminated sites.

With a grant from the Ontario Ministry of Housing and in partnership with the old City of Toronto's Environmental Protection Office, the Canadian Urban Institute prepared a guidebook for municipalities, public health officials and others, on how to create historical land use inventories of potentially

contaminated sites.

Background

Intensification is the redevelopment, primarily residential redevelopment, of already urbanized lands at (usually higher) densities capable of supporting public transit (Paehlke, 1990 p. 5). If cities can reuse previously developed lands they can accommodate their growing populations by making use of already existing infrastructure. At the same time intensification can redirect at least some development away from greenfields areas thus contributing to the reduction of urban sprawl. Thus intensification can save financial resources while at the same time reduce the negative impact urban areas have on the natural environment (Blais, 1996; Paehlke, 1990).

Much of the industrial and commercial land within Canadian municipalities is currently vacant or under utilized and provides an enormous opportunity for implementing intensification. However, due to past practices for managing industrial and commercial wastes, this land may be contaminated or contain other types of hazards. As a result, this land cannot be redeveloped without prior remediation. In Ontario alone there are many examples of interrupted and halted construction of redevelopment projects because unexpected hazards were encountered. For example, in Waterloo the discovery of tanks containing coal tar halted excavation for a new civic centre (Paul Eichenger, personal communication); workers at a new subdivision in Pickering complained of skin irritation and all work stopped when excessive lead was found in the soil (Waters and Fitchko, 1990); and, the groundwater pumped into the Ottawa River from an excavation for a transit way left an oily sheen and contaminated the river's sediments (Ontario Ministry of the Environment, 1987).

Purpose

A municipal historical land use inventory has been defined as a systematic collection of information on the type and location of past land uses that could have caused contamination of soil or groundwater. Developing historical land use inventories is a first step in the safe redevelopment of areas for intensification. The guidebook, *Historical Land Use Inventories A Guide for Ontario Municipalities*, aids municipalities in creating historical land use inventories. The guide was designed to provide municipalities with an understanding of the utility of historical land use information, the components of a historical land use inventory, and the tools to design an inventory to meet the unique needs of municipalities.

Applications of Historical Land Use Inventories (HLUI)

An inventory can be useful to various municipal departments. When a proposal to redevelop land is submitted to a municipal planning department, the location of the redevelopment can be checked with the inventory. If the site is present in the inventory, then the municipality may inform the proponent that an environmental site assessment is required to address potential environmental concerns. Other municipal departments that would make use of an inventory include: public works departments for investigating areas prior to excavating for new roads or services; and public health departments to meet guidelines for health programs and services.

The development and real estate industries need to know about the past uses on land that is already owned or about to be purchased. As an example, the real estate developers in Niagara Falls have become one of the most active users of the historical land use inventory within this municipality. Moreover, since members of the public and interest groups may also want access to this information, most sources of information used to create the inventory are publicly available[1]

Potential Benefits of a Historical Land Use Inventory

The time and effort needed to create a historical land use inventory can be justified by its benefits to a municipality. In addition to avoiding costly construction delays, the inventory would be important for determining areas within the municipality that may not be suitable for all land uses. In some cases, the cost of remediating contaminated sites could be prohibitive. In such cases, land uses may have to be chosen to fit the condition of the land rather than remediating the site to a state suitable for certain land uses such as housing.

Environmental protection programs such as ground water protection strategies would use an inventory to identify potential sources of contamination, as is being done in the Region of Waterloo in Ontario. In addition to historical land use information, the inventory can be expanded to include environmental information such as type of soil, proximity of watercourses or sensitive environmental receptors.

Methods of Development

The content and the methods were based on the information and experiences of the four municipalities in Ontario that have already created their own historical land use inventories: the City of Niagara Falls; the Region of Waterloo; the old City of Toronto; and, the City of Ottawa.

Two focus groups consisting of consultants, and municipal and provincial officials were held in Toronto and London to incorporate feedback from potential users of the guide. The result is a broadly based and researched document that provides options for large and small municipalities.

Creating a Historical Land Use Inventory

For a detailed description of the key steps in creating a historical land use inventory refer to the *Historical Land Use Inventories: A Guide for Ontario Municipalities*. The key steps are:

- defining the scope of the inventory;
- designing the inventory and selecting a presentation format;

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[1] The one major exception are fire insurance plans. In some cases the only copy of fire insurance plans for a site are held by Insurer's Advisory Organization (1989), Inc. In order to have access to them, interested parties must contact the organization. See section 5.2.3 - Historical Information Sources - of the Guide for more information.

- collecting the information, and;

- maintenance

Defining the Scope of a Historical Land Use Inventory

Defining the scope of the inventory involves identifying the objectives of the inventory's potential users and their requirements. These objectives are used to determine the contents of the inventory. Priorities may be set by considering: the type of land use activities, such as industrial or commercial uses; the scale of particular activities; certain geographic areas, including those under going pressure for redevelopment or proximity to environmentally sensitive areas; and the level of detail of the information sought. The content of the inventory can be selected from any of the seventeen information categories identified in the guide.

Designing the Inventory and Presentation Format

The differing needs and resources of different municipalities require that the guide allow for flexibility in the design of an inventory. To illustrate the variation in levels of detail and extent of possible inventories, three basic types are described in the guide:

1. *Areas of interest*. This type of inventory may be adequate for municipalities with limited resources and who wish to use the inventory as a tool for basic screening. It identifies and provides location information on areas which are of interest to the municipality. Such areas may include industrially zoned land, lands created by lake and land filling, waste disposal sites, sites occupied by potentially contaminating activities and sites under pressure for redevelopment (Figure 1).

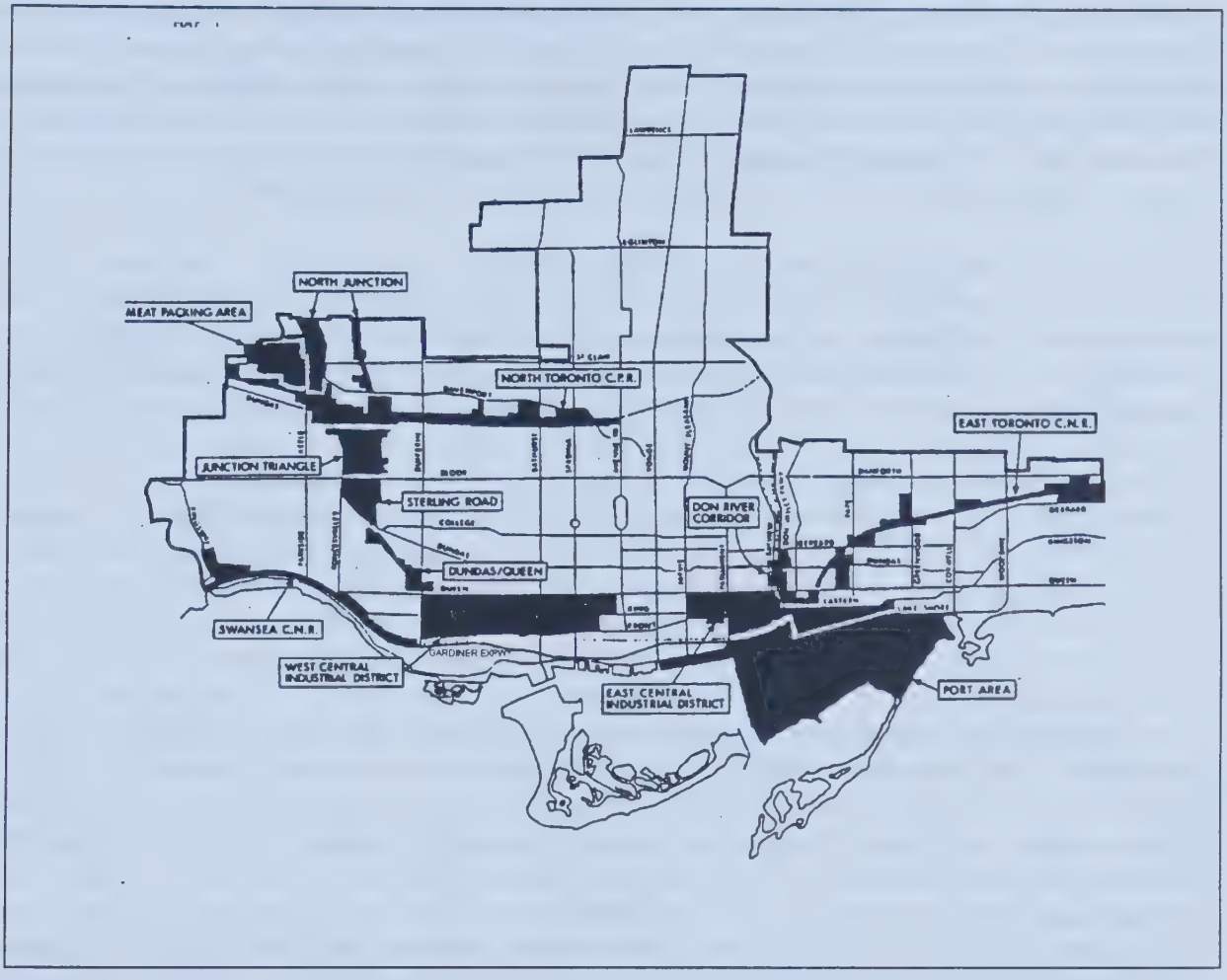
2. *Historical Land Uses*. This type of inventory includes the location information covered in the first type of inventory, but also includes more detailed information about specific past land uses at a given location (Table 1).

3. *Potential environmental concerns*. This type of inventory builds on information used to construct the first two plus information which can be used to assess potential environmental hazards. This information includes the location of **underground storage tanks, pits, lagoons, the scale of the industry and its products**, and physical features such as **surfici**al geology, proximity to water courses and well head protection areas.

A municipality's inventory could also be customized to include a combination of each type, or its own unique information categories depending on the requirements of the inventory.

The inventory information can be stored and presented in four different formats. The simplest format is a map which would illustrate the distribution and extent of potentially contaminating activities in the municipality (Figure 1). If more detail is required, a list containing addresses organized alphabetically could be used (Table 1). For larger lists, a computer database management system could be used to store information and search the inventory. Finally, the most complex format is a geographic information system containing layers of information on digitized maps.

Figure 1. Historical industrial areas from the City of Toronto's 1949 Official Plan



Address	Years	Company Name	Activity	SIC Code
401 North Street	1998	George's Iron and Steel	Scrap Metal	5919
	1968	George's Iron and Steel	Scrap Metal	5919
	1967	ABC Motor Sales	Motor Vehicle Repair Shop	6359
	1936	ABC Service Station	Gasoline Service Station	6331
	1917	ABC Junk Yard	Scrap Metal	5919
	1910	Residence		

Table 1. Example of a simple table inventory based on the Historical Land Use Database developed by the Environmental Protection Office, City of Toronto.

Collecting the Information

In creating a historical land use inventory, the project team noted that the collection of information is the most time consuming step and one most fraught with potential for problems. At this stage, the efficiency of information collection can be maximized and problems minimized by having taken care previously to define the inventory's scope. There are other ways to maximize collection efficiency. One is to start in the present and work backwards. Sites' street addresses often change. Working from the present backwards, will help flag such changes. Another way is to find a recent map, such as a city base map. Maps of all kinds are useful in that they help visualize the areas being analyzed.

There is a great number and variety of sources of information. It is important to remember that in most cases the sources were originally designed for purposes other than to document the location of potentially contaminated sites. This fact can make their use time consuming and frustrating. In choosing which sources to use, the municipality can select them according to the criteria of ease of use, reliability, comprehensiveness over time and space, and applicability to the information requirements of the inventory.

The information sources have been organized into five categories: municipal, provincial, historical, environmental and rural. For the simplest of inventories, municipal sources such as official plans, zoning by-laws, assessment roles, building permits, and aerial photographs may provide the required information. Such sources should be readily available to municipalities. Provincial sources of information in Ontario include inventories that contain that contain location and other information about underground storage tanks, waste disposal sites, PCB storage sites and coal gasification plans and related industries sites. These Provincial sources are relatively easy to use since they were designed to locate potentially contaminated sites. Moreover, they document some of the most environmentally hazardous sites.

While municipal and provincial sources may be readily available, historical sources must be used to determined any comprehensive history of land uses. Some of the most useful and easy to use sources of information are historical maps including fire insurance plans, land use atlases, and historical atlases. For instance, among other types of information, fire insurance plans indicate the location of hazardous and inflammable building uses, uses which often signal potential contamination. Unfortunately, many plans were destroyed as insurance coverage lapsed or new uses on sites required that new fire insurance plans be made. The various types of atlases have the benefit of being more comprehensive in their coverage, but also have less useful information.

Compared to the map based historical sources listed above, municipal directories are more comprehensive both with the respect to areas, and especially the time periods covered. They are divided in to sections including lists of occupants by street, and by business categories. However, using directories brings with it two drawbacks: they are time consuming to use and since they do not include maps their information can be difficult to interpret.

Other historical sources include industrial directories, title searches, Statistics Canada annual reports, county histories, histories by local historical societies, and interviews with long-time residents and municipal employees.

Environmental sources of information include various maps, surveys and reports produced by provincial government ministries such as the Ministries of Agriculture, Natural Resources, and Environment and Energy. The information addresses environmental features such as soil type, ground water vulnerability, vegetation type, water courses, marshes, and sensitive habitats.

In the past, development that has occurred in rural areas or villages is often not covered by historical sources such as fire insurance plans and municipal directories. Sources of information that do cover rural areas include past topographic maps, county histories and historical atlases, and inventories of abandoned pits, quarries and mines. Moreover, interviews with knowledgeable people such as long-term residents, and civic employees might also be conducted to help provide information not available from other sources.

Maintenance

Developing a complete historical land use inventory is an ongoing process requiring updates as more information becomes available. Even if the inventory is complete, changes to it may become necessary. For instance, an entry might be modified or even removed once a site has been redeveloped. The inventory might be expanded to include new categories, other industries or other hazards including unstable slopes and flood plains. It is likely the inventory will contain information gaps that can filled in over time as new information becomes available. This means that resources should be dedicated to maintaining the inventory.

Conclusions

Municipalities that have identified potentially contaminated sites will be better able to plan for intensification and redevelopment of their brownfields sites. In the long run, most areas of a city will be redeveloped. Having an up-to-date inventory of potentially contaminated sites can only serve to improve the efficiency of the redevelopment process and avoid expensive and disappointing surprises.

Historical land use that may have caused contamination of soil and ground water is only one of the environmental issues facing municipalities. Many of these issues are perhaps best addressed by municipalities that can provide local perspectives and approaches which lead to the most appropriate solutions. The variation and heterogeneity of the natural environment necessitates a local ecosystem approach to defining and solving these environmental issues. A local ecosystem approach will require decisions based on a wide variety of information not only on potentially contaminated sites but also on air and water quality, habitat, wetlands, wildlife, archaeological resources, water courses, groundwater, and other aspects of the natural environment.

An inventory of historical land uses can be a first step to more comprehensive environmental inventories that will provide information vital to the ecosystem approach and to planning for sustainability. The *Historical Land Use Inventories: A Guide for Ontario Municipalities* provides direction for creating part of the foundation on which sustainable communities can be built. Knowledge of the past is essential to building safe and enduring communities for the future.

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THE UTILITY OF AGGREGATE PROCESSING FINES IN THE REHABILITATION OF DOLOMITE QUARRIES

Jacquelyn Fraser and Ray McBride

Department of Land Resource Science
University of Guelph
Guelph, Ontario N1G 2W1

ABSTRACT

It is economically and environmentally desirable to use aggregate processing fines (pond fines), a by-product of dolomite crushing/washing operations, in the rehabilitation plans of the aggregate quarry where they are produced. A study was undertaken to determine if the physical and mechanical properties of these dominantly silt-sized materials also made them suitable as embankment material from a geotechnical perspective. The after-use proposed for the dolomite quarry investigated in this study (Milton quarry, Ontario) was to be a naturalized area surrounding a large water reservoir, and pond fines were being used to construct sloped embankments at the base of the vertical perimeter quarry walls for this purpose. The specific objectives were i) to measure and analyze the physical and mechanical properties of the pond fines that are relevant to their usage in site rehabilitation (earthen embankment), and ii) to predict the long term stability of the embankments given current emplacement practices and a scenario of partial submergence by a reservoir. Shear strength, measured by direct shear and drop cone penetrometer methods, increased with higher clay-sized particle content and higher dry bulk density, with lower sand content, and it peaked at soil water contents (4 to 9%kg/kg) well below the measured field capacity of about 16%kg/kg. Factors of safety calculated for slope stability (modified Bishop method of analysis) decreased with decreasing shear strength (cohesion, angle of shearing resistance), with increasing slope gradient, and with the introduction of a water table. Nevertheless, the factors of safety were acceptably high for all scenarios tested (≥ 1.8), including scenarios using the maximum measured slope gradient of 37%. Increasing the dry bulk density by 0.1 g/cm^3 over the mean density measured *in situ* (i.e., to about 87% of the Standard Proctor maximum dry density) did not improve the calculated factors of safety for slope stability enough to warrant increased mechanical compaction of the pond fines during embankment construction.

Introduction

Background

The aggregate industry is an important part of the construction sector of the provincial economy in Ontario, generating 141 million tonnes of aggregate in 1996 (O.M.N.R., 1996). High quality aggregate deposits are located in relatively close proximity to many rapidly growing urban centres in southern Ontario, which require granular material for highway construction, concrete and asphalt production, and fill purposes. Aggregate pits and quarries, however, can be disruptive to surrounding natural areas and to local residents as a result of various nuisances created (Baker, 1993). The duration of these disruptions can be shortened with the implementation of progressive rehabilitation guidelines and regulations (McLellan, 1985; Province of Ontario, 1995). Progressive rehabilitation involves rehabilitating an extracted area of a pit or quarry while continuing extraction in another part of the licensed area. Many decommissioned pits and quarries in Ontario have been converted to after-uses acceptable to local residents, but extraction below the groundwater table usually affects the land use options available (Baker, 1993).

The disposal of aggregate processing fines (pond fines), a by-product from washing crushed rock (dolomite), can represent a major economic burden at many quarries (Brown, 1995; Dukatz, 1995; Wood and Marek, 1995). The relatively high silt- and clay-sized particle content of this material makes it unsuitable as a commercial aggregate product (Dukatz, 1995). Some work has been done to find potential uses for pond fines such as agricultural products, ceramics, industrial minerals, and as fill or embankment material (Brown, 1995; Wood and Marek, 1995). Aggregate companies can potentially lower both rehabilitation and by-product disposal costs by utilizing by-products of their own operations in their rehabilitation plans wherever possible. If it can be demonstrated that pond fines or other by-products of aggregate processing can be used effectively in site rehabilitation, this will benefit both the aggregate producer and the state of the environment.

Site Description

The study site was located at the Milton dolomite quarry (467 ha), which is operated by Dufferin Aggregates and is situated on the Niagara Escarpment about 32 km west of Toronto (Pearson) International Airport (Figure 1). The primary plant is capable of producing up to 2000 tonnes of aggregate per hour and annual production has ranged from 4 to 8 million tonnes, making it the largest aggregate operation in Ontario. The quarry has been in operation since 1962, and Dufferin Aggregates has initiated a progressive rehabilitation plan in the southeastern end, which has been fully excavated. Pond fines from on-site sedimentation ponds have been used to construct sloped embankments about 7 to 8 m high at the base of the vertical quarry walls around the perimeter of the mined area. This medium-textured material has been emplaced by "ramping" it up the slope and compacting it to some degree (Trow, Dames and Moore, 1989). No deliberate mechanical compaction has been carried out, apart from normal wheel/track traffic by earth moving equipment.

The study area was a 650 m length of embankment in a state as described above, but other portions of the quarry embankment were in a more advanced state of progressive rehabilitation (started in the late 1980's) at the time that this study was undertaken. In these areas, loam-textured forest topsoil material (removed from licensed areas being prepared for mining) had been placed over the embankments. Natural vegetation had been allowed to establish and some woody species had been planted (Zimmerman *et al.*, 1998). Timely revegetation of newly emplaced embankments is important to slope maintenance due to the highly erodible nature of the medium-textured pond fines.

The dolomite formation being extracted extends below the level of the regional groundwater table, therefore pumping has been necessary on a continuing basis to dewater the site. Once extraction of the entire licensed area is complete, pumping of groundwater will cease and the quarry will be transformed into a reservoir with a submerged area of about 271 ha (Trow, Dames and Moore, 1989; Zimmerman *et al.*, 1998). The naturalized embankment slopes will provide shallow areas along the reservoir edge (about 14 km of shoreline) capable of supporting both aquatic and terrestrial plant and animal species. Since the quarry is located on the Niagara Escarpment (a UNESCO World Biosphere Reserve), and close to the associated Bruce (hiking) Trail, the creation of both wildlife habitat and dispersed (low intensity) recreational areas are important objectives of the rehabilitation plan, in addition to providing a large open water reservoir.

Study Objectives

It is expected to take almost 20 years for the quarry to fill with water to its final design depth, at which point the perimeter embankment will be submerged to about midway up its slope (Trow, Dames and Moore, 1989). There is little information available in the published literature on the physical and mechanical properties of fine dolomite clastics under different degrees of saturation that would permit the assessment of the long term stability of these embankments at the Milton quarry. The specific objectives of this study were i) to measure and analyze the physical and mechanical properties of the pond fines that are relevant to their

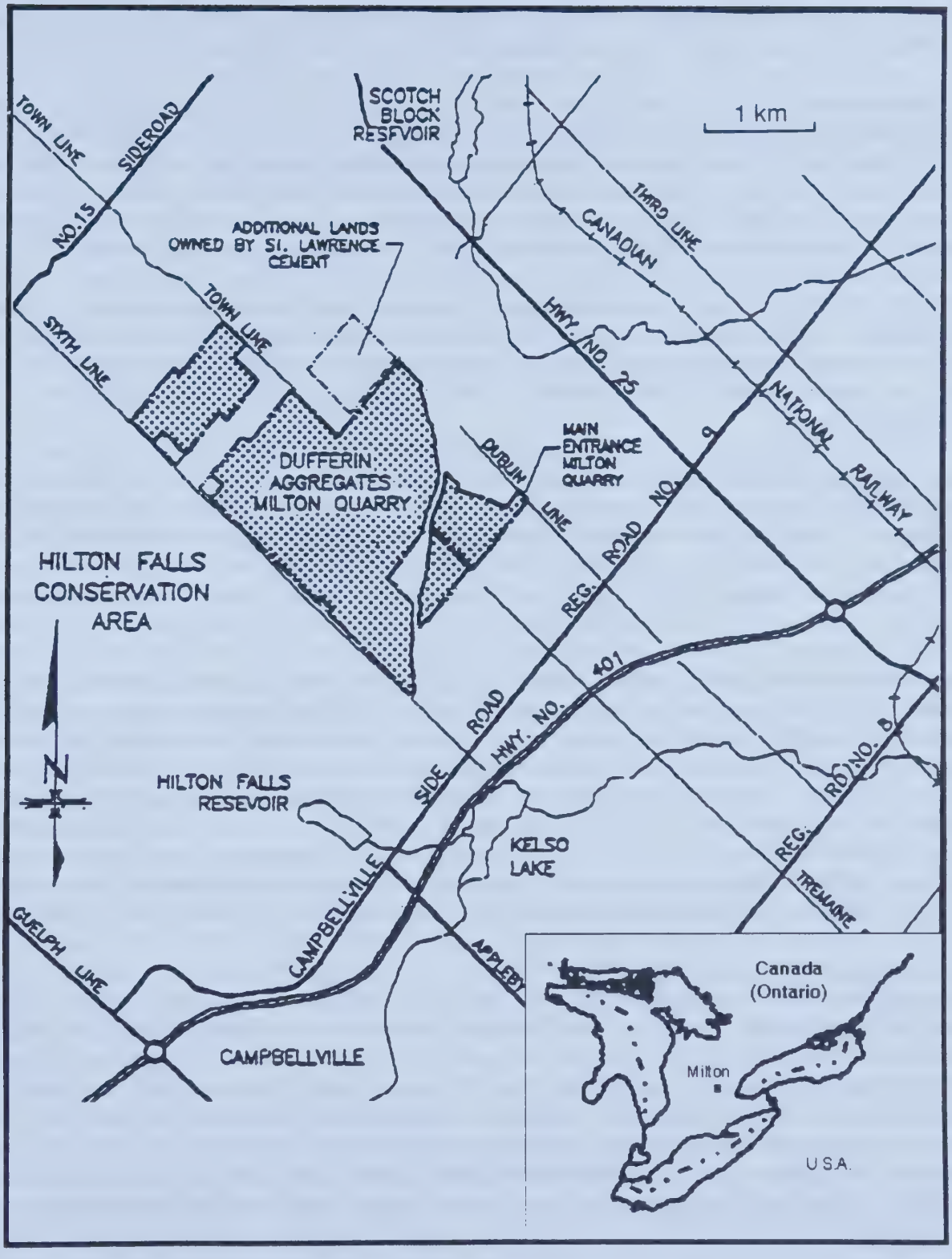


Figure 1 **Locational map of the Milton quarry in southern Ontario (after MacNaughton Hermsen Britton Clarkson Planning Ltd.)**

usage in site rehabilitation (earthen embankment) at the Milton quarry, and ii) to predict the long term stability of the embankments given current emplacement practices and a scenario of partial submergence by a reservoir.

Study Methodology

Theodolite and Terrain Conductivity Surveys of Embankment

A 650 m long section of the embankment located at the southeastern end of the quarry was chosen as the study area, and it was surveyed using an infra-red theodolite (Wild model T1600) to determine the existing slope dimensions. The survey data were downloaded into a mapping program, which was used to create a contour map of the embankment and to determine the range of slope gradients that existed.

A pre-study survey of apparent electrical conductivity was also carried out on the embankment with a Geonics EM31-D non-contacting terrain conductivity meter. Autocorrelation analysis showed that i) there was no spatial dependence in these readings and, therefore, there was unlikely to be any in several other important soil properties such as water content and dry bulk density, and ii) a sampling interval of about 10m was appropriate.

Physical Properties of the Pond Fines (Field)

Sixty-two sampling stations were flagged at 10-metre intervals along a mid-slope transect running perpendicular to the embankment contour. A bore hole (5 cm diameter) about 1.2 metres deep was drilled at each sampling station. The material from each bore hole was placed in a plastic bag to be used as a composite sample for particle-size distribution and shear strength testing. Thin-walled aluminum access tubes (1.3 m long x 5.0 cm i.d.) were placed in the holes with 15 cm protruding from the soil surface.

A CPN density-moisture depth gauge (CPN Model 501DR Depthprobe) was used to measure the *in situ* wet bulk density (ρ_t - g/cm^3) and volumetric soil water content (θ - % m^3/m^3) at each sampling station, for the purpose of generating dry bulk density profiles (ρ_d - g/cm^3). The probe was lowered into the access tube and three repeat measures of gamma and neutron counts were taken at seven different depths (15 cm increments) below the soil surface: 22.5 cm, 37.5 cm, 52.5 cm, 67.5 cm, 82.5 cm, 97.5 cm, and 112.5 cm. Mean count ratios for the three repeat counts at each depth were converted to ρ_t and θ values using calibration equations supplied with the instrument. Dry bulk densities were calculated from the ρ_t and θ values for all measurement depths at each station, and the θ values were also converted to gravimetric soil water content (w - % kg/kg) so that w values from lab tests could be compared directly to field soil water contents.

Physical Properties of the Pond Fines (Lab)

The hydrometer method was used to determine the particle-size distribution for the composite samples collected from the bore holes at each of the 62 sampling stations (Gee and Bauder, 1986). Two test repetitions were completed for each sample. Total sand, clay, and silt contents (% kg/kg) were calculated. Based on the hydrometer testing, samples from four different sampling stations were chosen which represented the full range of particle-size distribution observed in the embankment of pond fines. These four samples were subjected to more detailed analysis (e.g., shear strength, Standard Proctor Density testing). The more precise pipette method (Gee and Bauder, 1986) was also carried out (two repetitions) on these four samples to corroborate the hydrometer particle-size distribution results. Sand fractionation was carried out by wet sieving.

Mechanical Properties of the Pond Fines (Lab)

Standard Proctor Density test. The maximum dry bulk density (MDD) and optimum water content (OWC) of the four samples selected for detailed investigation were determined using the Standard Proctor Density test (A.S.T.M., 1981). The ASTM D698 tests were repeated three times for each sample. A fourth order

polynomial equation was fitted to the data to aid in the determination of precise MDD and OWC values.

Determining the effect of sample disturbance and full saturation on shear strength. Due to the cohesionless nature of the material being tested, it was not practicable to extract and transfer structurally intact samples from the field to a direct shear apparatus in the lab for shear strength testing. To study the effect that sample remoulding had on measurable shear strength, a preliminary series of drop cone penetration tests (Houlsby, 1982) was carried out on undisturbed core samples at field water content, which were subsequently remoulded, repacked and retested at the same water content.

Aluminum sampling rings (5 cm high x 4.7 cm i.d.) were used to carefully collect structurally intact soil cores at the surface (16 cores) and at a 30 cm depth (16 cores) at randomly selected locations on the embankment. The core samples were tightly wrapped in plastic bags to maintain them at the field soil water content until penetrometer testing was conducted. The core sample was trimmed carefully using a thin blade to create a flat surface for drop cone penetrometer testing. Up to twelve penetration readings were taken per core.

After being tested in an undisturbed state, the samples were removed from the sampling rings and remoulded in their original sample bags to minimize water loss. The pond fines were then repacked to the same initial ρ_t in the sampling rings in three lifts using an impact compaction apparatus with a 3.0 kg rammer. The drop cone penetrometer tests were repeated as above, and the mean penetration depths (mm) for the undisturbed and corresponding remoulded samples were compared using a Student's t-test to detect significant differences.

An additional 16 undisturbed core samples were taken on the embankment for drop cone penetration testing under fully saturated conditions. This testing would determine the extent of strength loss with saturation of this cohesionless material, and possibly whether there was any evidence of thixotropic behaviour (Maerz and Smalley, 1985). The base of each core was wrapped with porous, acrylic fabric to allow handling when fully saturated. The cores were placed in a tray which was slowly filled with distilled water to the upper level of the sampling rings. Drop cone penetration testing was carried out as above.

Direct shear testing. The shear strength parameters, cohesion (c) and angle of shearing resistance (ϕ), were determined for the four samples (remoulded) using the direct shear method, or ASTM D3080 (A.S.T.M., 1981). Four different normal loads were used for each sample (0.2, 0.4, 0.6 and 0.8 kN), and the test was repeated three times for each normal load. All tests were conducted at a constant horizontal strain rate of 2 mm/min. The samples were first tested at the mean field ρ_d measured along the embankment (1.62 g/cm^3) and at six target water contents (air dry, 1, 2, 3, 5 and 12%kg/kg). Actual w values were calculated by weighing subsamples at both the beginning and end of a given test, drying them for 24 hours at 105°C, and reweighing. The measured w values, rather than the target values, were used in all data analyses.

Testing was also done at a higher ρ_d in order to determine the effects of initial density on the shear strength of the pond fines. It was found that the highest ρ_d that could be attained by applying the maximum achievable static load of 5 kN in the direct shear apparatus was 1.72 g/cm^3. Even this ρ_d value could only be attained at water contents between 2 and 12%kg/kg, as air dry soil could not be compressed to this degree in the shear box. Shear tests were carried out at this higher ρ_d for four target soil water contents (2, 4, 6, and 12%kg/kg). Actual w values were calculated as above.

Horizontal and vertical forces and displacements were recorded by a data logger during each shear test. From these data, the maximum horizontal force and the corresponding vertical force were converted to

shear and normal stress values, respectively, by dividing by the area of the sample's shearing plane. These stress values were then plotted and a straight line was fitted to the points by simple regression in order to determine the two shear strength parameters (c, ϕ).

Drop cone penetration testing. For comparison with the direct shear results, the shear strength of the same four samples (remoulded) was also tested using the drop cone penetration method described above. Samples were compacted to two different ρ_d values in large sampling rings (3.6 cm high x 7.6 cm i.d.) using the same impact compaction apparatus mentioned above, but fitted with a larger impact plate. Three replicate samples were created for each combination of ρ_d (1.62 and 1.72 g/cm^3) and target soil water content (air dry, 2, 6, 8, 10 and 12%kg/kg), for a total of 36 samples. Twelve penetration readings (mm) were taken on each core surface. Again, actual w values were calculated by weighing subsamples at both the beginning and end of a test, drying them for 24 hours at 105°C, and reweighing.

A smaller series of penetration tests was carried out on three of the samples at ρ_d of 1.9 g/cm^3, a density approaching the Standard Proctor MDD for these samples. This density could only be achieved at the high end of the w range used in this study (8, 10 and 12%kg/kg). The fourth sample could not be compacted to this density at any water content, even using the maximum drop height and rammer weight available on the impact compaction apparatus.

Modeling Slope Stability

Factors of safety (FOS) were calculated using a computer program based on the modified Bishop method for slope stability analysis (Bishop, 1955; Craig, 1992). Three different slope angles were considered based on the contour map created from the theodolite survey, representing the maximum, minimum and "typical" slope gradients. Two hydrological scenarios were considered. First, the embankment was modeled in its current unsaturated state (i.e., no groundwater table) by simulating scenarios involving combinations of i) the three slope gradients, ii) the two ρ_d values (1.62 and 1.72 g/cm^3), and iii) the shear strength parameters measured for each of the four texturally-disparate soils at the highest target soil water content (12%kg/kg).

Next, FOS were calculated for the same soil and topographic conditions as above, except that a horizontal groundwater table was simulated at a level 3.5 m above the base of the embankment. This was approximately midway up the 7 to 8 m high embankment, and was the final design depth of water proposed for the reservoir. To model this hydrological scenario, an underlying phreatic (submerged) zone was simulated employing the same ϕ values used for the unsaturated pond fines, but assuming zero cohesion and saturated unit weights.

Results and Discussion

Soil and Site Characteristics

The theodolite survey produced information on the range of slope gradients present on the study area portion (650 m) of the embankment. The minimum measured slope gradient was 15.4% (8.7°, or 6.4:1), the maximum slope was 37.0% (20.1°, or 2.6:1), and the "typical" slope was 25.6% (14.4°, or 3.7:1).

The dry bulk densities (ρ_d) ranged from 1.30 to 1.87 g/cm^3 across all depths at the 62 sampling stations. The mean ρ_d did not vary appreciably with depth (about 1.62 g/cm^3), indicating little natural consolidation of this material with time in the upper 1.2 m. The gravimetric soil water contents (w) ranged from 9.1 to 23.4%kg/kg across all depths and sampling stations. The overall mean of 16.1%kg/kg was also relatively consistent with depth, although the uppermost measurement depth (22.5 cm) showed some evidence of surface drying by early summer. Autocorrelation analysis confirmed the preliminary conclusion from the EM31-D survey that there was no spatial dependency in the ρ_d, w or particle-size distribution data.

The particle-size distribution of the emplaced material (hydrometer method) varied considerably along the embankment, although i) virtually all of the samples belonged to the silt loam textural class, and ii) this textural variation was not reflected in the ρ_d or w profiles. The sand and clay contents showed much higher coefficients of variation than the silt fraction. The 62 sampling stations were organized into four clusters based on the hydrometer data, using a k-means clustering analysis function. This function places samples into a user-defined number of clusters based on the variable in question (i.e., particle-size distribution), with the goal of minimizing the variability within clusters and maximizing that between clusters. A single representative sample was chosen from each of the texturally-disparate clusters for further detailed study. For example, sample #15 had the highest proportion of silt, sample #42 had the highest proportion of sand, and sample #11 had a particle-size distribution that was the closest to the overall mean across the embankment (Table 1). All but sample #42 (sandy loam) belonged to the silt loam textural class (Table 1).

	Effective Diameter Range (mm)	Percentage of Total Sample (%)			
		#11	#15	#42	#51
Very coarse sand	1.0 - 2.0	2.3	2.1	1.2	1.3
Coarse sand	0.5 - 1.0	2.4	1.6	1.4	0.8
Medium sand	0.25 - 0.5	2.8	1.4	1.3	0.6
Fine sand	0.10 - 0.25	6.0	2.5	12.7	4.8
Very fine sand	0.053 - 0.10	13.8	10.8	46.5	33.8
Total Sand	0.053 - 2.0	27.3	18.3	63.0	41.3
Total Silt	0.002 - 0.053	61.8	69.1	33.6	50.5
Total Clay	< 0.002	10.9	12.6	3.4	8.2

Table 1 **Particle-size distribution results for four selected samples (pipette method)**

The results of the Standard Proctor Density tests performed on the four samples are presented in Table 2. Significant differences among the mean test indices were more pronounced in the MDD values compared to the OWC values. Particle shape and grading are known to influence both test indices (Panayiotopoulos, 1989). Coarse-grained soils will normally compact to higher densities than fine-grained soils with the same compactive effort, and will also have correspondingly lower optimum water contents. Sample #42, which had the highest sand content of the four soils tested (sandy loam), did yield the highest MDD and the OWC was also significantly lower than two of the other three samples. Sample #11, which was most representative of the mean particle-size distribution along the embankment, also had a statistically intermediate MDD of 1.98 g/cm^3 (Table 2). If we take this MDD to be representative of the mean textural conditions on the embankment, then the mean field ρ_d of 1.62 g/cm^3 corresponded to about 82% of this reference Standard Proctor MDD. This confirmed that the embankment was not overly compacted or consolidated.

Shear Strength

General strength characteristics. The drop cone penetrometer was used to determine whether structural disturbance of this cohesionless material would cause a significant change in shear strength. The depths of drop cone penetration generally increased after samples were repacked, as compared to the penetration

Sample #	†Mean MDD (g/cm^3)	Coefficient of Variation (%)	†Mean OWC (% kg/kg)	Coefficient of Variation (%)
11	1.98*b*	0.001	10.9*a*	0.58
15	2.01*b*	0.008	10.7*ab*	1.16
42	2.06*a*	0.001	9.4*b*	4.70
51	1.92*c*	0.007	11.0*a*	3.38

† means of Maximum Dry Density (MDD) or Optimum Water Content (OWC) that are denoted with the same lower case letter are not significantly different at $\alpha = 0.05$.

Table 2 **Standard Proctor density test results for four selected samples**

depths measured on structurally intact cores at the same field water content. Cone penetration was found to increase significantly ($\alpha = 0.05$) after remoulding for 13 of the 16 surface core samples taken (Student's t-test). All 16 samples taken at the 30 cm depth had significantly ($\alpha = 0.05$) greater cone penetration depths after remoulding. Since the drop cone penetration test is a rudimentary measurement of a soil's shear strength, this test indicates that there are interparticle bonds present in this material that significantly contribute to soil strength and that will be ruptured by remoulding. Hence, shear strength measured on remoulded samples (e.g., direct shear) is likely to be lower than that actually present in the field. It can be concluded that slope stability predictions made on the basis of the shear strength measures on remoulded samples will be somewhat conservative (i.e., true FOS will be understated).

The drop cone was observed to freely penetrate the full length of the core under fully saturated conditions. The cone penetration depth was well in excess of 20 mm, the depth of penetration considered to coincide with the liquid limit of plastic soils (i.e., viscous fluid consistency). Even though the pond fines are non-plastic, this result indicates that there is negligible cohesive strength when saturated. These saturated core samples did not appear to exhibit true thixotropic behaviour, despite clay-sized particle contents of up to 19%kg/kg. Clay-rich soils exhibiting quick or sensitive behaviour seem to require a mixture of non-expanding phyllosilicates and primary minerals in their clay-sized fraction (Maerz and Smalley, 1985).

Direct shear. Direct shear testing was carried out on the four samples at the mean field ρ_d (1.62 g/cm^3) and at the highest density that could be attained with static loading in the direct shear apparatus (1.72 g/cm^3). Tests were run over a range of gravimetric soil water contents from air dry up to about 12%kg/kg. It was found that 12%kg/kg was approximately the highest soil water content yielding a distinct maximum horizontal stress, which was necessary in order to obtain results for shear strength at failure. Plots of maximum horizontal shear stress (or shear strength [τ_f]) versus vertical stress (or total normal stress [σ_f]) were created, and a simple regression line was fitted to the data in order to define an equation (Coulomb failure criterion) for each sample and combination of initial w and ρ_d conditions as follows:

$$\tau_f = c + \sigma_f \tan \phi \qquad (1)$$

The responses of the shear strength parameters with changing w and ρ_d are summarized in Figures 2 and 3 (1.62 g/cm^3). Both linear and second order polynomial functions were needed to adequately fit these relationships. A density as high as 1.72 g/cm^3 could not be obtained, using a maximum achievable static load of 5 kN, for soils drier than 1.7%kg/kg or for sample #42.

Figure 2 shows the effect of w on cohesion for samples prepared at a ρ_d of 1.62 g/cm^3. The regressions of

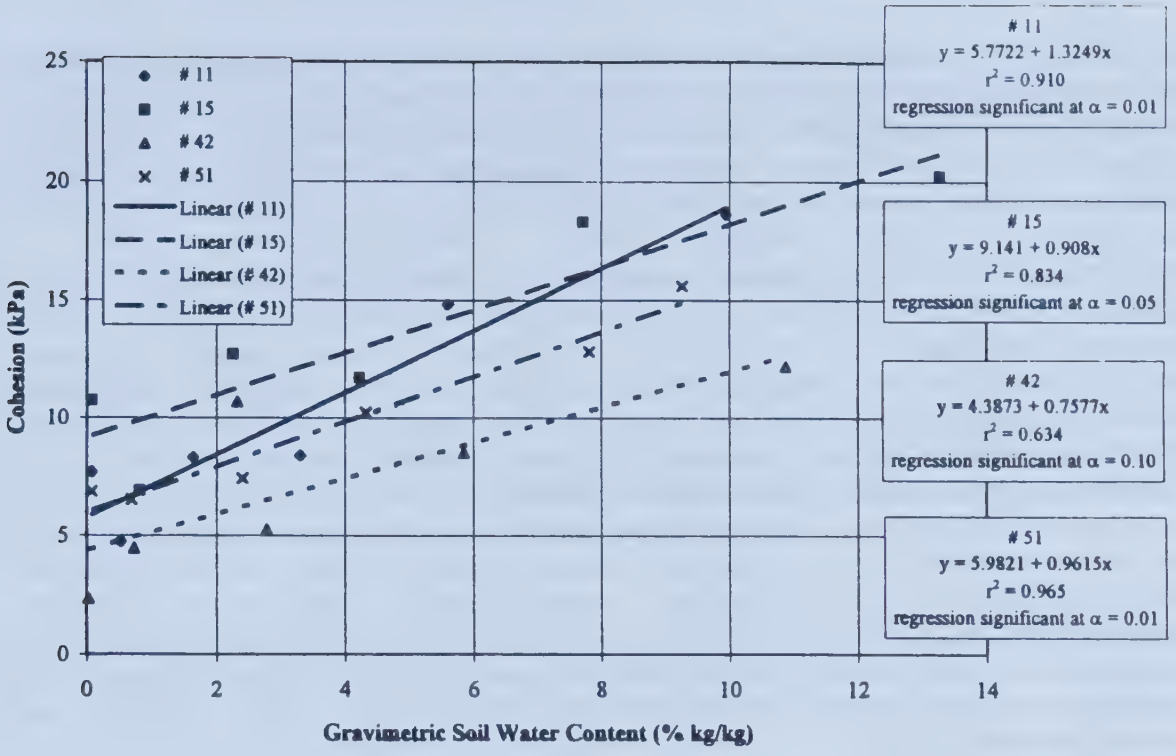


Figure 2 **Soil cohesion vs. water content at a dry bulk density of 1.62 g/cm^3**

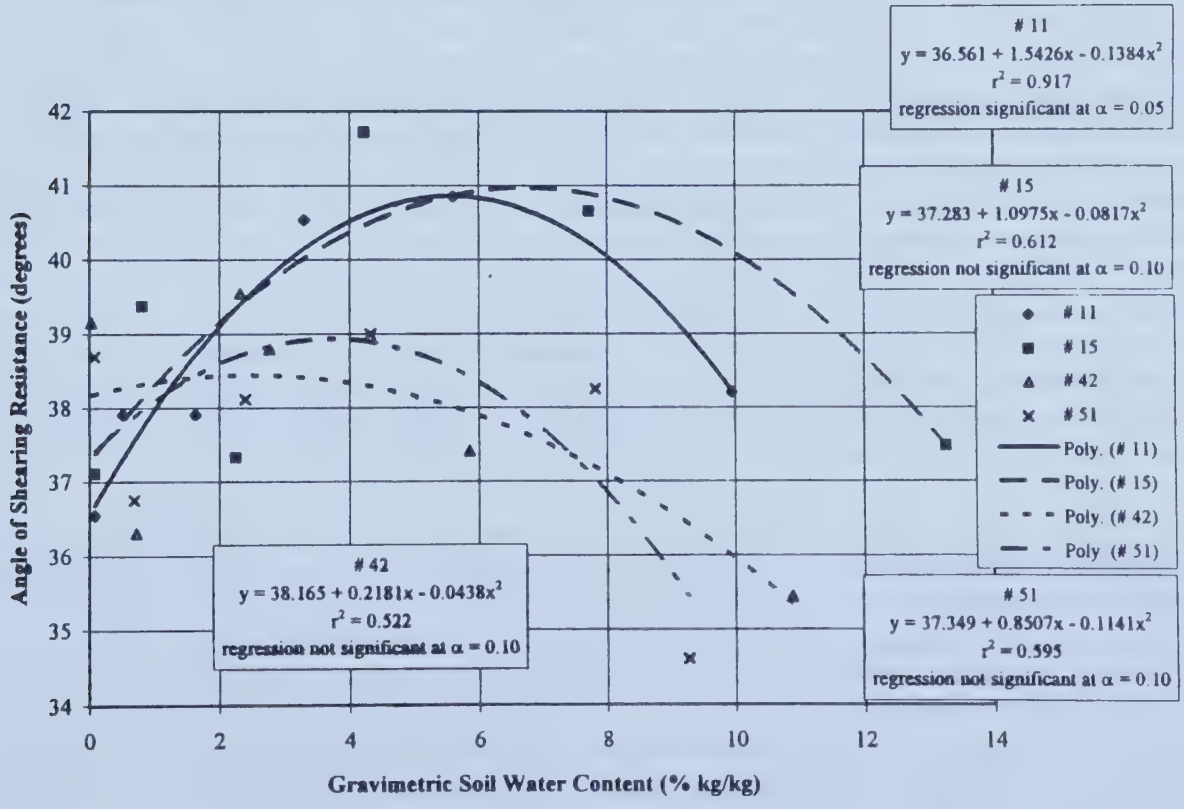


Figure 3 **Angle of shearing resistance vs. water content at a dry bulk density of 1.62 g/cm^3**

cohesion versus w for samples #15 and #51 at a ρ_d of 1.72 g/cm^3 were not significant at $\alpha = 0.10$ and therefore no statistical contrasts were done on these results. An increase in ρ_d, however, seemed to result in a corresponding increase in cohesion at an equivalent w for three of the samples. As ρ_d increases, the measurable cohesion normally rises due to increased interparticle contact (Panayiotopoulos, 1989). The cohesion values for sample #51 at a w of about 10%kg/kg, however, were very similar for both densities.

For samples at a ρ_d of 1.62 g/cm^3, cohesion increased linearly over the range of w tested (Figure 2). The relationship between c and w in plastic soils is frequently found to be curvilinear, similar to that found for these non-plastic pond fines at a ρ_d of 1.72 g/cm^3. At this higher ρ_d, cohesion seemed to increase up to a w of about 6 to 8%kg/kg and then decrease, however the quadratic regressions were not significant at $\alpha = 0.05$ (the quadratic regression for sample #11 was significant only at $\alpha = 0.10$). It has been widely observed that a plastic soil's cohesion increases with w until it reaches a maximum close to the plastic limit, and then decreases (Nichols, 1932; Wells and Treesuwan,1978). It will be shown from the results of the drop cone testing (Figure 4) that the w at minimum cone penetration coincides with that at maximum cohesion for samples prepared at the higher ρ_d (1.72 g/cm^3). The point where the plot of drop cone penetration depth versus w reaches a minimum is a good estimator of a cohesive soil's plastic limit (Campbell, 1976). Although this material is clearly non-plastic and therefore has no measurable plastic limit, some parallels can be drawn. It is reasonable to assume that cohesion would eventually reach a maximum and then begin to decrease in the samples prepared at the lower ρ_d (1.62 g/cm^3) at more elevated water contents (Figure 2).

Cohesion seemed to be influenced also by the particle-size distribution of the samples tested. Two of the three regressions for the samples prepared at the higher ρ_d (1.72 g/cm^3) were not significant at $\alpha = 0.10$, and therefore no further statistical contrasts were made. The linear regressions for the lower density samples were all significant at $\alpha = 0.10$ (Figure 2) and contrasts were carried out using the General Linear Models (GLM) procedure in PC-SAS. Sample #42 (sandy loam), with the highest sand and lowest clay-sized particle contents, was found to have significantly lower cohesion than samples #11 and #15 ($\alpha = 0.05$) over the range of soil water contents tested. Therefore, a decrease in sand and an increase in clay-sized particle contents gave rise to an increase in cohesion. Greater clay-sized particle contents will result in a greater proportion of the total porosity comprised of micropores, which can retain water at considerable negative pore water pressures contributing to soil cohesiveness.

Figure 3 shows the effect of w on ϕ for samples prepared at a dry bulk density of 1.62 g/cm^3. There was some evidence of a curvilinear relationship in most samples, but the only significant regression ($\alpha = 0.05$) was for sample #11 at the lower ρ_d (1.62 g/cm^3). As a result, no statistical contrasts were made. It was concluded from the lack of statistical significance that ϕ is not sensitive to the degree of saturation of the pond fines, which is normally the case for granular materials (Craig, 1992).

An increase in ρ_d did not seem to cause an appreciable increase in the ϕ shear strength parameter. For example, the ϕ of sample #11 over a w range of 1.5 to 10%kg/kg varied from 37.9 to 40.9° at the lower ρ_d (1.62 g/cm^3), and from 37.3 to 38.0° at the higher ρ_d (1.72 g/cm^3). Since an increase in ρ_d results in an increase in interparticle contact, this should bring about an increase in friction and thus in the angle of shearing resistance. This effect was observed only very slightly in samples #15 and #51 at higher w values. There was a tendency, however, for the overall range of ϕ values measured at the higher density to be skewed into the upper end of the range observed at the lower density (Figure 3). The relatively small difference in ρ_d of 0.1 g/cm^3 between the two density treatments was probably insufficient for clear distinctions in ϕ to be observed in this material.

The distribution of size fractions between 0.002 and 0.25 mm (fine sands, very fine sands and silts) in the

pond fines appears to have the most influence on the angle of shearing resistance. A shift to smaller particle-sizes in this range will increase the ratio of surface area to mass of the particles which will tend to increase interparticle friction and ϕ (Panayiotopoulos, 1989). The maximum ϕ observed for samples #11 and #15 at the lower ρ_d (1.62 g/cm^3) was about 41° (Figure 3). These two samples have relatively similar particle-size distributions and contain the highest silt and lowest fine/very fine sand contents of the four samples tested (Table 1). The maximum ϕ values for samples #51 and #42 were about 39° and 38.5°, respectively. More than half of the 0.002 to 0.25 mm component of sample #42 is fine and very fine sand, and would therefore be expected to have the lowest ϕ of the four samples.

Drop cone penetration. The drop cone penetrometer was used to further study the shear strength of the four samples over a wider range of w and ρ_d than was possible with the direct shear box apparatus. Figure 4 shows the relationship between the depth of drop cone penetration and w for a ρ_d of 1.62 g/cm^3. It was found that the maximum rammer mass and drop height available with the impact compaction apparatus was not sufficient to achieve a ρ_d of 1.90 g/cm^3 (i.e., 96% of the reference MDD) in samples drier than 6%kg/kg or for sample #42.

The depth of cone penetration showed a strong quadratic relationship with w (Figure 4) and significant regressions ($\alpha = 0.05$) were attained for all but sample #51 at the two lowest ρ_d values (1.62 and 1.72 g/cm^3). The GLM procedure in PC-SAS was used to perform statistical contrasts (second order polynomial model) between cone penetration depths for the two lowest densities. An increase in ρ_d resulted in a decrease in drop cone penetration depth, and this shear strength increase was significant $\alpha = 0.01$. For samples #15, #51 and #42, the depth of cone penetration decreased (indicating an increase in shear strength) as the sand content decreased and clay-sized particle content increased. The direct shear testing revealed similar results. Sample #11 appeared to exhibit the lowest cone penetration depths at its minimum, however the curve is the steepest of the four samples and it intersects the other curves.

The depth of cone penetration decreased from air dry to a w of about 6 to 9%kg/kg, then increased with increasing w (Figure 4). It is known that the plastic limit of cohesive soils corresponds to the w at which cohesion is at a maximum (Nichols, 1932), and at which cone penetration is at a minimum (Campbell, 1976). Although this applies only to plastic soils, where the drop cone test measures the undrained cohesion, a parallel can be drawn to the w of the pond fines where the maximum cohesion values and minimum drop cone penetration depth are reached. This was best illustrated in the higher density treatment (1.72 g/cm^3).

The shear strength of pond fines reaches a maximum at soil water contents considerably lower than the field capacity, and this strength can be increased by increasing ρ_d. This observation is consistent with the results of the direct shear box testing. Again, samples of higher clay-sized particle content and lower sand content seemed to exhibit higher shear strengths.

Slope Stability Analysis

Factors of safety (FOS) for rotational (circular) slope failure were calculated using a computer model based on the modified Bishop method of slope stability analysis (Bishop, 1955). The maximum (37.0%), minimum (15.4%), and "typical" (25.6%) slope gradients were used in these simulations. Input data on the shear strength parameters for unsaturated conditions were taken from the direct shear test results for the four samples at the mean field ρ_d of 1.62 g/cm^3. Values used for c and ϕ were taken at the w closest to the measured field capacity of 16%kg/kg (i.e., the highest target w that could be used in the direct shear apparatus was 12%kg/kg [Figures 2 and 3]). An analysis was also done at the higher ρ_d (1.72 g/cm^3) to determine if increased effort by the aggregate company in mechanically compacting the embankment was warranted.

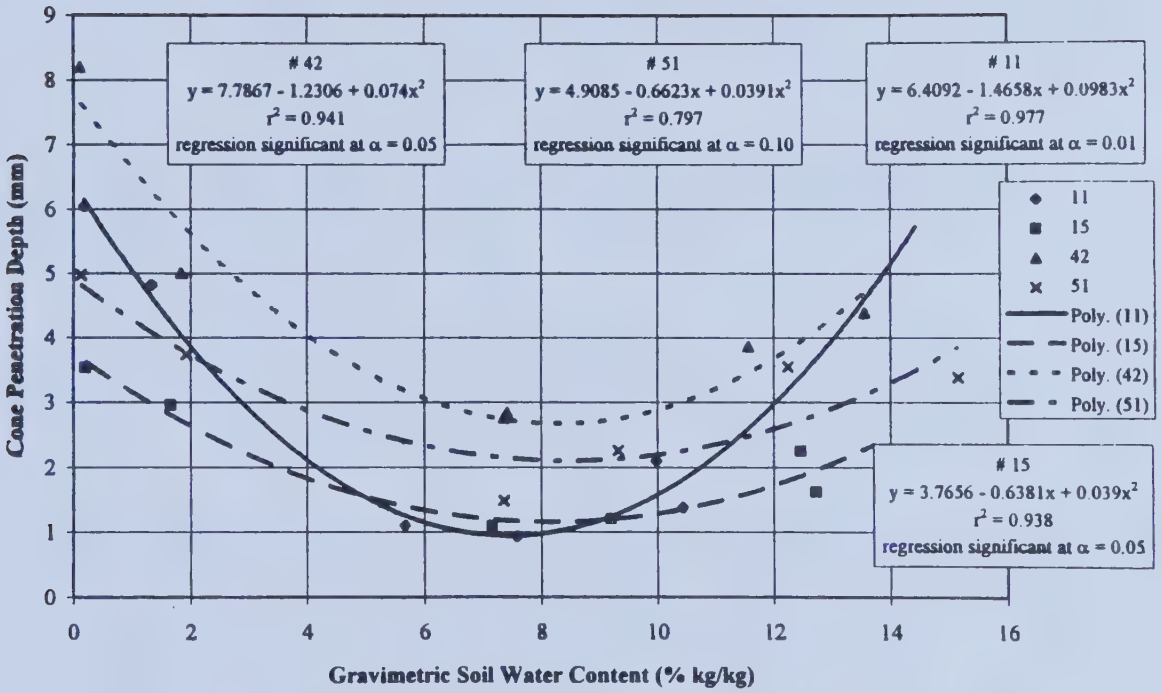


Figure 4 **Depth of cone penetration vs. water content at a dry bulk density of 1.62 g/cm^3**

The first hydrological scenario represented the current condition with an unsaturated embankment (i.e., no groundwater table). The second hydrological scenario included a horizontal groundwater table at the 3.5 m level above the base of the embankment, thus producing two zones; an unsaturated (vadose) zone with the same shear strength parameters as the first hydrological scenario, and a saturated (phreatic) zone below the groundwater table with the same angle of shearing resistance as for the unsaturated zone, but with saturated unit weights and an assumed cohesion of zero. The zero cohesion assumption is amply supported in the literature (Craig, 1992), as well as by the observation from this study that there was virtually no resistance to drop cone penetration in saturated core samples of the pond fines. The shear strength of this material at saturation, therefore, is assumed to be a solely a function of the friction component of Eqn. [1]. Table 3 shows the input parameters used in the slope stability analysis for saturated and unsaturated pond fines.

Unsaturated (Field Soil Water Content)						
	ρ_d = 1.62 g/cm^3			ρ_d = 1.72 g/cm^3		
Sample #	ϕ (°)	c (kPa)	γ (kN/m^3)	ϕ (°)	c (kPa)	γ (kN/m^3)
11	38.2	18.6	17.45	38.0	21.9	18.24
15	37.5	20.2	17.98	40.5	21.3	18.64
42	35.4	12.2	17.60	---	---	---
51	34.6	15.6	17.35	37.6	14.6	18.60
Saturated						
	ρ_d = 1.62 g/cm^3			ρ_d = 1.72 g/cm^3		
Sample #	ϕ (°)	c (kPa)	γ (kN/m^3)	ϕ (°)	c (kPa)	γ (kN/m^3)
11	38.2	0	19.69	38.0	0	20.29
15	37.5	0	19.69	40.5	0	20.29
42	35.4	0	19.69	---	---	---
51	34.6	0	19.69	37.6	0	20.29

Table 3 **Input parameters used in the slope stability analysis**

The failure surface yielding the lowest FOS was determined iteratively by the computer model and these values are reported in Table 4. In this study, a FOS of 1.2 or higher was considered acceptable for earthen embankments (Craig, 1992). Table 4 shows that the FOS using the modified Bishop's method was 1.8 or higher for all of the scenarios tested. The steepest slope angle on the embankment (37.0%) yielded FOS values ranging from 1.8 to 4.7, whereas the lowest slope (15.4%) yielded FOS values ranging 4.7 to 9.1. Dry bulk density, however, had a more complex influence on the FOS. For example, an increase in unit weight would normally have the effect of decreasing the FOS, however this was often negated by an increase in the shear strength parameters at higher ρ_d values. The direct shear box testing showed that sample #42 at the lower ρ_d possessed the lowest cohesion of the four samples, and this resulted in the lowest FOS for the vadose scenario.

Slope Gradient	Water Table	Dry Bulk Density (g/cm^3)	Sample #			
			11	15	42[+]	51
Minimum (15.4%)	no	1.62	8.8	8.8	7.8	8.2
		1.72	9.0	9.1	---	8.1
	yes	1.62	5.2	5.0	4.7	4.5
		1.72	5.1	5.6	---	5.1
Typical (25.6%)	no	1.62	5.4	5.4	4.5	4.8
		1.72	5.2	5.2	---	4.6
	yes	1.62	2.9	2.9	2.7	2.7
		1.72	2.9	3.2	---	2.9
Maximum (37.0%)	no	1.62	4.4	4.4	3.5	3.8
		1.72	4.6	4.7	---	3.8
	yes	1.62	2.0	2.0	1.8	1.8
		1.72	2.0	2.2	---	2.0

[+] direct shear testing could not be performed on sample #42 at 1.72 g/cm^3, and as a result, its shear strength parameters are unknown.

Table 4 **Minimum factors of safety against rotational failure calculated using the modified Bishop method of analysis**

There was a dramatic decrease in FOS when a horizontal groundwater table was introduced in the scenario testing (Table 4). Nevertheless, the same trends observed in the vadose scenario can be seen in the effects of ρ_d and particle-size distribution on the FOS for the vadose/phreatic scenario.

Conclusions

The shear strength parameters of the pond fines were found to be adequate to maintain a stable embankment with slope gradients of up to 37%, whether the embankment was unsaturated or partially submerged. Material with higher clay-sized particle content and lower sand content possessed higher measured shear strength. The measured angles of shearing resistance, some in excess of 40°, are somewhat higher than for other granular materials with similar particle-size characteristics, possibly due to the angularity of the clastics from the dolomite crushing operations. Even though the pond fines material is classified as cohesionless, it does have measurable cohesion at water contents below field capacity which is attributable to effective stresses caused by the presence of water menisci in micropores. This material has virtually no measurable cohesion when saturated, however the angle of shearing resistance is likely to be adequate to maintain the embankment's stability within the range of slope gradients found on the embankment studied. Any overestimation of ϕ (and hence the FOS) in the phreatic zone due to the inability to conduct direct shear tests on saturated pond fines is likely to be compensated for by the underestimation of FOS caused by using remoulded samples for direct shear testing. Modification in the current methods used to construct the embankment might achieve a higher degree of compaction (i.e., >82% of reference Standard Proctor MDD [1.98 g/cm^3]), but this did not appear to be warranted from the slope stability analysis results. Timely

revegetation of newly emplaced embankments, and possibly the installation of biotechnical slope stabilization structures, will be important to the long-term maintenance of acceptable slope gradients by preventing sheet/rill erosion and undercutting of the embankment by reservoir wave action.

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RAPID ECOLOGICAL INVENTORIES FOR ECOLOGICAL RESTORATION OF INDUSTRIAL LANDS

Stephen Murphy
Greg Michalenko
Jason Whitfield

Department of Environment and Resource Studies
University of Waterloo

Larry Lamb

Faculty of Environmental Studies
University of Waterloo

Roger Suffling

School of Planning
University of Waterloo

ABSTRACT

Ecological inventories are critical for the success of site planning, implementation, and monitoring in ecological restoration of industrial lands. Inventories of large areas may need to be completed quickly because ecological restoration projects are often opportunistic. As part of a multi-phase ecological restoration project at an industrial site, we designed ecological inventories completed by 15 undergraduates during 5 days as part of a course exercise. Historical records, air photos and 1-day reconnaissance of vegetation patterns were used to delineate provisional community boundaries (13 communities total). We then intensively sampled for 4 days using random Z-walks to identify weeds, natives, and confirm community boundaries. Forty soil and water samples for pH, moisture, and nutrients (selected randomly and in areas with probable eutrophication) revealed provisional boundaries for the communities were accurate and most areas had high nitrogen and phosphorus. Weeds will continue to invade and soil impoverishment may be needed, though old building foundations are already adequate for planning alvar habitats. Circle calling surveys indicated there were 60 common bird species that could be supported with the creation of interior forest habitat and construction of boxes, brushpiles, and raptor poles. Pit, Sherman, and Hav-a-Heart mammal and herptile traps proved inadequate as they failed to account for behaviourial patterns, age-size distribution, and food preferences. Our rapid survey served its main purpose of allowing more detailed site planning but better mammal and herptile surveys are needed to ensure a functional ecosystem is re-established on site. The survey information we collected was combined with information from a previous urban environmental planning study to construct an initial design for long-term ecological restoration at our study site.

Introduction

Ecological restoration on industrial lands is one aspect of the emerging field of industrial ecology (Côté and Plunkett 1996). One general difficultly with ecological restoration is the need to perform rapid assessments in order to expedite the planning and implementation of a project. This can be exacerbated in industrial situations because the need for more immediate tangible outcomes is often greater than on public lands. We do not imply

that the project must sacrifice scientific principles; rather, the datasets to be used will be less complete than if assessments and inventories over several seasons were possible. Generally, this can be accommodated by consulting historical databases to supply missing information about what species and functions were important on the site pre- or post-industrialization. Additionally, it is unrealistic to restore a site to a supposed pristine state. The best approach is to use a nearby reference community or ecosystem to gauge what is likely appropriate on the site, in terms of the biophysical limitations (see Aronson et al. 1995, Pickett and Parker 1995 for discussion). On-site monitoring for a short period (e.g. several months) can add necessary details about slope, bedrock, hydrology, soil conditions, contamination, extant populations of organisms, dormant populations of propagules (e.g. plant seeds). Some data will be omitted by this approach but if the alternative is lose the opportunity to restore a property, then this is acceptable. This especially is true where the restoration site still has some industrial activity in existence and the risk of lost opportunity may be greater as a corporation must quickly justify expenditures on restoration projects with visible results. In this sense, ecological restoration at industrial sites is a microcosm of the long debate over the best approaches to restoration and the conflict between pragmatism and science (see Bradshaw 1993, Cairns 1993, Cairns and Pratt 1995, Jackson et al. 1995, Hobbs and Norton 1996).

Since most industrial sites already are severely ecologically degraded, restoration efforts are unlikely to worsen conditions unless large-scale alterations of hydrology or other landscape-scale processes are planned. Such cases are likely rare as restoration ecology, especially on working industrial lands, tends to focus initially on creating small-scale communities with individuals adapted to the current (degraded) conditions that eventually will help direct succession towards other valued communities. Rather than attempt to micro-manage succession, industrial ecological restoration should work within biophysical limitations to create naturalized communities that meet the ecological requirements and, importantly, are consistent with shared social goals of the restoration experts and the client. These goals will be influenced by the ecological requirements but also will be affected by corporate culture, economic constraints, and aesthetic ideals. This is not novel to industrial ecology but it is vital to recognize this explicitly and act accordingly.

We will discuss how (and how quickly) an ecological inventory be performed for the purpose of supplying information for the planning and implementation of the ecological restoration of an industrial site in Niagara Falls, Ontario. Our research is based upon the precept that certain indicator taxa (often species) are most useful in planning and implementation (see Oliver 1993, Williams 1993, Oliver and Beattie 1996a, b, Small et al. 1996).

Site Description. The Cytec Canada plant in Niagara Falls Ontario was used for our study. Cytec Canada has asked the Universities of Guelph and Waterloo to devise a restoration plan for the majority of the lands on their site. These lands are abandoned and not likely to be used in further production.

Surveys. All of the surveys were completed during a 5 day period in July 1997 by the authors and a class of 15 undergraduates. Data were compiled and analyzed within a week of survey completion.

Soil Survey. Because the site was (and is) industrial, we needed to determine the general texture and evidence of any eutrophication or other pollution. We sampled in non-disturbed areas because this indicated the existing soils that support relatively native communities and allows us a reference state for planning restoration. There was little existing information about the site itself, though we were able to reconstruct the past 50 years of use from old surveying notes. We divided the site into thirteen putative communities, based on visible vegetation, and sampled to determine if the soils were different between these communities. We used a stratified random Z-walk sample that varied positively with the area's size. The sample size was kept small (100 samples in total) to expedite testing. Again, this does not provide a detailed site analysis but should detect severe problems with soil structure. Sampling was performed with a soil auger for detailed testing and a backhoe for testing of texture and saturation. In the laboratory, we tested one-quarter of all soil samples for nitrogen, phosphorus, and humus (using Anonymous' [1975] test), and pH (portable pH meter). Texture was determined visually. Saturation was

an observed property, i.e. how many hours did it take for a pit to fill (assuming it did not rain in the interim).

Texturally, much of the site is underlain with clay with silty or sandy loam on top. The site is riddled with old concrete building foundations as well as cinders and gravel from old building used as fill. This presents a challenge in restoration as organisms (e.g. trees, large shrubs) needing large and deep root systems will not flourish. As a consequence, we are planning the site to include meadow and prairie habitat. Several areas were saturated because of underground seepage (probably because old buried foundations prevent water drainage). This means some areas may be suitable for small wetlands. Most areas were suitable for these habitats as the nitrogen levels were around 11 kg/ha (low concentrations), the phosphorus levels were sufficient to support plant growth (100-200 kg/ha), and the pH was generally slightly acidic (6.5-7.0). There were some areas where nitrogen was extremely high (>150 kg/ha), especially in bodies of water or around decommissioned buildings where ammonium nitrate was produced. These sites will require amendments such as mulch to impoverish the soil to a level that will discourage weedy invasives and allow natives (especially prairie grasses) to compete effectively. Humus levels in these areas tended to be low, meaning that there is likely insufficient organic matter and aeration to support most weedy plants. In other areas, however, there is sufficient humus to support shrubs but this also will support weeds; inert mulches may prevent weed establishment where shrubs can be transplanted (from other areas on-site) as root-pruned plugs. Still other areas that are planned as shrub-dominated habitat may require more humus; again, this will require an anticipatory strategy to prevent weed establishment.

Water Survey. All watercourses were tested to ensure the water quality was sufficient to support plant and animal communities. We collected five 1 L samples and tested for conductivity (Orion Model 160 meter), turbidity (Hach 2100 A Turbidmeter), chlorides (argentometric method), phosphates (stannous chloride method), iron (phenanthrolene colorimetry), nitrates (cadmium reduction colorimetry), and sulphates (turbidmetric method) (Greenberg et al. 1992). We found high turbidity (meaning streambank rehabilitation is needed should there ever be a project to restore fish habitat) as well high chloride, sulphate, phosphate, conductivity (many other dissolved ions). The ionic indicators demonstrate that the streams are polluted and unsuitable for most desirable (native) vascular plants, fish, herptiles, and invertebrates.

Vegetation Survey. Using Riley (1989) and Anonymous (1997) as a guide to ranking species by rarity, all thirteen putative vegetation communities were surveyed using a random walk in a Z-shaped transect across the entire width and length of each habitat. The fields were walked twice by at least 4 different team members (there were 8 surveyors in total). Dominant species were identified and recorded every 20 m. Our survey indicated a high number of weedy species (not unusual considering the amount of old building fill on-site) which will require initial management by herbicides, mulch, or other methods but has the potential to become a prairie habitat (e.g. Wilson and Gerry 1993). Prairies are useful at our site because they are sufficiently low-lying and will not create safety hazards by blocking the sight-lines of various areas of the industrial plant Monitoring plots will be constructed because the propagule bank will have to be examined over several years to predict future weed problems. The survey was used to identify native forbs, herbs, shrubs, and trees that could be used in transplanting to restoration sites or as part of an on-site nursery. We intend to avoid using non-indigenous species in our efforts (see Bradshaw 1993) and will attempt to use a bioregional approach to restoration, i.e. using locally-adapted genotypes.

Sites on corporation property but away from the actual industrial site can be used to supply a small amount of plugs or seeds (see also Lippitt et al. 1994) but we are to use commercially grown stock for most restoration efforts. The corporation lands had a variety of habitats: slough forest, wet mid-successional fields, agricultural lands, hedgerows, floodplain meadows, wetlands, riverine forests, transportation corridors, and, of course, decommissioned buildings (or their rubble, as incorporated into the soil). The vegetation surveys indicated that the borders assigned to these communities were arbitrary but the plants did indicate the fundamental state of abiotic factors such as nitrogen, pH, soil texture. For example, downy brome (*Bromus tectorum*) heavily infested sandy soils with slightly acidic pH and medial levels of nitrogen. The old building foundations were rife

with weeds but probably will make an excellent substrate for alvars. Most of the other parts of the industrial site harbours drought-tolerant aliens and natives with shallow roots because of the large amount of rubble on top of the clay foundation. Exceptions are in depressed areas where little rubble exists and the clay creates wet meadows and wetlands. Our intention is to minimize further disturbance of the areas with less rubble; these are undergoing autogenic succession. The rubble-strewn areas are the ones most in need of restoration. We plan to use hardy natives (e.g. goldenrods, Solidago) to help out-compete weedy aliens (e.g. common sow-thistle [Sonchus oleraceus]). Because nitrogen is not particularly high, we can use nitrogen-fixing species (though we cannot plant so many that nitrogen levels rise to the threshold where nitrophilous weeds will dominate).

Generally, the vegetation communities are amenable to restoration at relatively low-cost; our biggest challenge will be to ensure that the communities are not highly fragmented to avoid edge effects that will affect not only the plants but the animals that occupy the habitats (e.g. Zink et al. 1995)

Bird Survey. Birds are excellent indicators of the relative complexity of habitats, i.e. in terms of trophic structure and physical fragmentation. They are a key top-down control of insects in ecosystems and promote seed dispersal (of both natives and aliens). On the advice of our colleague, Ted Cheskey (Waterloo County Board of Education), we used a circle calling method. Eleven stations were chosen using a relévé method (i.e. distinguish habitats on the basis of their visible vegetation and select a putative representative sampling location within each). Around dawn each day, 5 or 6 people surveyed each station for 10 minutes and recorded every bird (based on visible observation or song) on a circular grid representing the survey area. The bird's actions were recorded (e.g. feeding, singing, flying, nest tending, parental care). Breeding-related activities are proportional to the number of visible observations; this is crude estimate of the suitability of habitats to sustain reproductive populations of birds. Most species are territorial and the identity of the species indicates how wide a territory is needed and available. This is indirect evidence of the state of the industrial site, i.e. how much restoration may be needed.

There were over sixty species of birds, mainly natives, at our site. Our survey indicated that the open fields were adequate habitat for species such as northern mockingbird (Mimus polyglottos) and raptors (e.g. red-tailed hawk, Buteo jamaicensis) but the lack of snags requires the installation of raptor poles. This will help regulate pest populations of non-native predators on-site (e.g. feral cats), excessive populations of rodents that can damage plants, and provides aesthetic enhancement for the workers and any visitors on-site. Interior species (e.g. ovenbirds) were infrequent because of habitat fragmentation and the parasitism by edge species such as brown-headed cowbird (Molothrus ater). The fragments will need to be linked with native vegetation to reduce edge effects; there was no evidence of fragments harbouring isolated populations of diseases or parasites, hence linking fragments poses little risk. Still other bird species will require vegetation that has been eliminated or reduced by fragmentation and invasive plants. For example, several breeding ruby-throated hummingbirds (Archilochus colubris) exist on-site but these are constrained by a lack of suitable plants, e.g. native honeysuckles (Lonicera), because of excessive light and competition from species such as garlic mustard (Alliaria petiolata) that tend to self-perpetuate advancement of edges along fragments.

Mammal and Herptile Survey. Like birds, mammals and herptiles are useful indicators for restoration projects and they have aesthetic appeal. Mammals and herptiles can be more difficult to survey (more labour-intensive and expensive because, typically, traps are needed) and they can be more gregarious and less site-specific. We used forty-five pit traps for surveys of rodents and herptiles. The traps were made from soup cans and coffee containers with punctures (to allow drainage). Thirty-eight Sherman traps were used to capture rodents only; they were baited with peanut butter, shell-on peanuts, and pieces of apple. Mid-sized mammals (rabbits, raccoons, opossums) were sampled using twelve Hav-a-Heart traps baited with the same materials as the Sherman traps. Traps were placed randomly along established mammal trails within each vegetation community and checked every 12 hours.

Most mammals were found in the mid-to-late successional habitats (old fields and forests); this is expected as there is less external disturbance and greater niche availability. The vole and mice populations did not appear to be excessive (we captured only 4 individuals), though once restoration begins it is expected these

numbers will increase (hence the recommendation for raptor poles in the previous sub-section). The results obtained generally were inadequate as the number of traps and baits used failed to account for behaviourial patterns, age-size distribution, and food preferences. The baits used could not attract carnivorous mammals. The amounts of bait need to be varied to account for differences in optimal foraging patterns; these patterns are, in turn, related to the age and size of an animal. The pit traps did not capture herptiles and a more-labour intensive survey is needed; herptiles are useful indicators of the status of vegetation, soil, and water within habitats but we believe our other surveys satisfied this role. We still intend to sample herptiles to determine if there are any rare species on-site that will require refinement of restoration plans. The main utility of the trapping was that we attempted to attract pest species that could harm vegetation during restoration and found that the numbers were not excessive at present.

Implications. This study was not designed as a comprehensive scientific approach; the purpose was to maximize and expedite collection of specific information needed for planning restoration in an industrial context. We succeed in identifying major features, such as whether the soil and water were contaminated, the availability of plants for restoration, habitat fragmentation and the ability to support bird species, and the presence of mammalian pests. Our conclusions are conjectural and we are initiating a scientific monitoring program on-site to ensure a more comprehensive approach; however, this will require several years to complete. This time frame is not suitable to the needs of ecological restoration of an industrial site but is useful to ensure the restoration works. Our surveys indicated the site was ecological degraded but there was sufficient material and ecological function to allow a relatively inexpensive restoration plan to be designed and implemented. +

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LANDSCAPE ECOLOGY APPROACHES TO THE SUSTAINABLE MANAGEMENT OF MINERAL AGGREGATE RESOURCES, OAK RIDGES MORAINE, ONTARIO, CANADA

John Z. Fraser

Ontario Ministry of Natural Resources
Peterborough, Ontario

ABSTRACT

This paper describes a conceptual framework for the management of mineral aggregate resources in the rapidly developing Greater Toronto Area (GTA) in Ontario, as part of an emerging resource management philosophy based on concepts of ecological sustainability and landscape ecology. Existing GIS-based Landscape Ecology Analysis Programs (LEAP) can be adapted to produce structural indices which can be derived for simulated extraction scenarios and evaluated for significant deviation from natural landscape patterns in the Oak Ridges Moraine landscape. A Decision-Support System based on the analysis and modeling of these scenarios permits the evaluation of landscape-scale mineral aggregate resource management strategies which emulate natural disturbance patterns within the limits of natural variation in landscape composition. Such an approach would also support the evaluation of alternate rehabilitation strategies for extracted areas to emulate natural structural components of the moraine landscape. This approach provides a DSS for the integration of mineral aggregate resource management into an ecologically sustainable approach to the management of the entire landscape.

Submission #1
PAPER

Ecological Restoration of Meadowlily Woods

D.T. Kraus[1] (presenter), B.J. Dowsley[1], T. W. Hilditch[1] and R. Knutson[2]
[1]ESG International, 361 Southgate Drive, Guelph, Ontario, N1G 3M5
tel: (519) 836-6050, fax: (519) 836-2494, e-mail: dkraus@gesp.com
[2] Knutson & Associates, 360 Queen's Avenue, London, Ontario, N6B 1X6

Environmental approvals for the development of a servicing tunnel within a mature sugar maple - white ash forest demanded the creation and implementation of a complex ecological restoration plan. A mix of proven and experimental techniques were used to prepare the site and manage plant materials. These techniques included: seed/propagule/soil storage, removal of forest plugs, tree planting and the re-introduction of forest litter. Forest plugs were used to provide both native tree materials and sources for the re-colonization of woodland herbs. Topsoil was banked to provide both a seed/propagule source and organic material. Restoration work was conducted from 1994 to 1996. A total of 240 forest floor plugs were temporarily stored in specially designed structures prior to transplantation. These plugs contained over 35 different native species. Early results indicate that techniques used to accelerate forest succession have been successful. Most woody and herbaceous species within the plugs survived transplantation. Difficulties encountered during the project included invasion of the site and stored forest plugs by non-native meadow species and low survivorship of seed/propagules in the stock-piled soil. Succession at the site now appears to be directed towards a young sugar maple - white ash forest. A variety of natural successional processes have also contributed to the restoration of the site.

THE REHABILITATION OF THE GLENRIDGE QUARRY LANDFILL SITE

Susan L. Girt, M.C.I.P., R.P.P., Proctor & Redfern Limited, Hamilton, Ontario, Canada
David G. Smith, P.Eng., City of St. Catharines, St. Catharines, Ontario, Canada

ABSTRACT

The focus of this paper is to describe the development and the features of the End Use Master Plan for the Glenridge Quarry Landfill Site in St. Catharines, Ontario. The Landfill, originally a mined-out limestone quarry, is located on the brow of the Niagara Escarpment within a developed area of the City of St. Catharines and is required to close by December 31, 2001. Conditions of approval require that the Landfill be progressively rehabilitated to a passive natural state and an End Use Master Plan be prepared to achieve this goal. The closure of the Landfill also offers a unique opportunity to provide side trails and significant viewing areas to the Bruce Trail and municipal trail system.

In order to develop an End Use Master Plan acceptable to the residents of the City of St. Catharines, regulatory agencies and municipal politicians, a comprehensive public consultation program was implemented.

The End Use Master Plan includes planting plans to progressively rehabilitate the site as well as an implementation schedule and costs. Key elements of the End Use Master Plan include the development of wildflower and tall grass areas, an extensive trail system and information/interpretative signs. The site infrastructure (i.e. monitoring wells, Landfill Gas Collection and Flaring System, etc.) must remain accessible but be protected. The development of the End Use Master Plan for the Landfill also provided an opportunity to dialogue with other people involved with other local naturalization projects.

Keywords: Glenridge Quarry Landfill Site, St. Catharines, Ontario, Rehabilitation, End Use Master Plan

INTRODUCTION

Proctor & Redfern Limited was retained by the City of St. Catharines to develop an End Use Master Plan for the Glenridge Quarry Landfill Site. Proctor & Redfern Limited is an employee owned, multi-disciplinary, Canadian consulting firm with extensive experience in the field of waste management.

The City of St. Catharines, with a population of 130,000, is located on the Niagara Peninsula in Southern Ontario, approximately fifteen kilometres (nine miles) northwest of Niagara Falls, Ontario. The City operates the Glenridge Quarry Landfill Site, as an agent for the Regional Municipality of Niagara (Regional Niagara), an upper-tier municipality, which assumed waste management responsibility within the Niagara Region on January 1, 1997. The City of St. Catharines will continue to operate the landfill site as an agent for Regional Niagara until one year after closure (December 31, 2002).

The Glenridge Quarry Landfill Site operates under a Certificate of Approval issued by the Provincial Ministry of the Environment (M.O.E.) to receive municipal waste excluding commercial waste not collected by municipally contracted forces and industrial waste. The current service area for the Landfill includes the City of St. Catharines, City of Thorold and the Town of Niagara-on-the-Lake.

PURPOSE OF THIS PAPER

This paper describes the development and the features of the End Use Master Plan[1] for the Glenridge Quarry Landfill Site.

Condition No. 15.1 of the Certificate of Approval requires that an End Use Master Plan for the Glenridge Quarry Landfill Site be submitted to the Director of the M.O.E. by November 7, 1998.

Condition No. 15.1 states the following:

> *"The End Use Master Plan shall be submitted to the Director within two years of the issuance of this Certificate."*

Condition No. 15.8 also states:

> *"The Landfill shall be progressively rehabilitated to a passive natural state and developed with a trail system as described in the End Use Concept Plan and to be developed in the End Use Master Plan to be prepared as described in condition 15.1."*

LOCATION OF THE SITE

The property for the landfill site was acquired by the City in December 1975 and landfill operations commenced in October 1976. The site is a 44.58 hectare (110 acre) site located in south St. Catharines on a boundary road with the City of Thorold.

The landfill site is located within a mined-out limestone quarry on the brow of the Niagara Escarpment. The Niagara Escarpment is a massive ridge of sedimentary rock extending across the Province of Ontario, 725 kilometres (450 miles) from the Bruce Peninsula to the Niagara Peninsula, and reaching 511 metres (1,675 feet) in height in some locations. Canada's oldest marked hiking trail, the Bruce Trail, runs along the Niagara Escarpment for over 800 kilometres (500 miles).

HISTORY OF THE SITE

The first Certificate of Approval for the Glenridge Quarry Landfill Site was issued in 1976, however, the Certificate was amended several times to reflect landfill development and changes in landfill monitoring programs. A second Provisional Certificate was issued on August 14, 1986 and was subsequently amended.

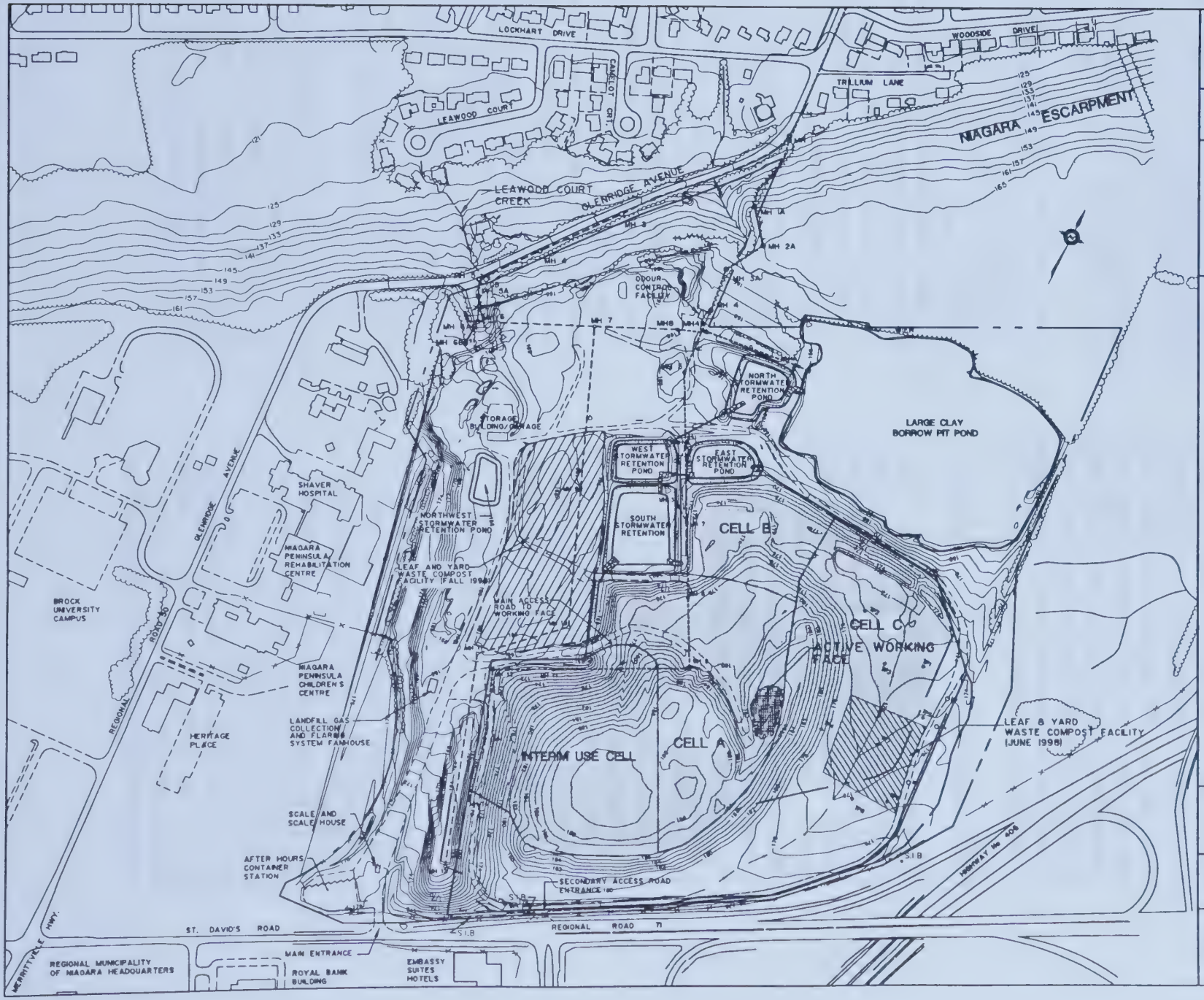
In January 1995, applications were submitted to the M.O.E. and the Niagara Escarpment Commission (N.E.C.) for the Grade Modification Proposal to permit landfilling until December 31, 2001. The Grade Modification Proposal was approved by the N.E.C. on October 24, 1996 and by the M.O.E. on November 7, 1996.

The Glenridge Quarry Landfill Site was one of the first sites in Ontario to be constructed with a clay liner, leachate collection system and stormwater management system. Additional infrastructure at the site now includes a Landfill Gas Collection and Flaring System, Groundwater Collection Trench and an Odour Control Facility.

Map 1 illustrates the location and existing conditions of the Glenridge Quarry Landfill Site.

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[1] "End Use Master Plan, Glenridge Quarry Landfill Site", City of St. Catharines, Proctor & Redfern Limited, June 1998



City of St. Catharines

GLENRIDGE QUARRY LANDFILL SITE

EXISTING SITE CONDITIONS

(AS OF JUNE 1998)

LEGEND

- TOTAL SITE AREA (44.58Ha)
- HISTORIC WASTE DISPOSAL FILL AREA (17.35Ha)
- APPROVED WASTE DISPOSAL FILL AREA (12.6Ha)
- 180 — EXISTING CONTOUR ELEVATION AS OF JUNE 1998 (MASL)[1]
- DRAINAGE DITCHES
- MAIN EFFLUENT SEWER & MANHOLE
- GROUNDWATER COLLECTION TRENCH & MANHOLE
- SECURITY FENCE
- TREES

NOTE:
① ALL CONTOUR ELEVATIONS NOTED IN METRES ABOVE SEA LEVEL (MASL).

MAP 1

Scale: 0 100 200m

Proctor & Redfern Limited
Professional Consulting Services

DEVELOPMENT OF THE END USE MASTER PLAN

Original End Use Proposal

An End Use Proposal was presented at a public hearing before an environmental approval board in 1975, although it was not made a condition of the original approval of the Glenridge Quarry Landfill Site. The proposal included athletic sports fields, a tea garden, open space and parking areas. It was recognized that this proposal was only a concept and that further investigation would need to be carried out before an end use of this nature was recommended for the site.

End Use Concept Plan

As part of the Grade Modification Proposal, an evaluation of alternative end uses was completed for the landfill site to reassess and determine the most suitable use of the closed Landfill. An evaluation methodology and criteria were developed in consultation with government review agencies and the public, and the following end use alternatives were evaluated:

- Golf Course or Driving Range
- Naturalization Area/Regeneration to Natural Area
- Passive Recreational: Trail System for Walking, Jogging, Cycling, Roller Blading, Cross-Country Skiing, etc.
- Horticultural Garden or Horticultural Research Area
- Active Recreational: Sports Arena, Outdoor Sports Fields or Active Recreational uses
- Residential Development within buffer lands
- Inert Fill Site to Rehabilitate Quarry/Excavated Areas

The evaluation concluded that the most suitable end use for the Landfill would be natural revegetation of the Landfill and the establishment of a trail system. The concept of a long-term inert fill site was rejected but it was recognized that clean fill must be accepted at the Landfill during the Grade Modification Proposal disposal period and for a period of time after the Landfill is closed to provide adequate fill material for final cover and rehabilitation purposes. Based on this end use, an End Use Concept Plan was developed and was submitted as part of the Grade Modification Proposal supporting documentation.

Recommendations of the end use evaluation include the following:

- The closed Glenridge Quarry Landfill Site should be developed with an end use consisting of natural revegetation and a trail system.
- The City accept suitable fill material during the Grade Modification Proposal planning period and if required, for a period after Landfill closure for final cover and Landfill rehabilitation purposes.
- Vegetation planted at the site should consist of species that are native to the area (i.e. Carolinian Forest) and in accordance with a detailed landscaping plan.
- Trails should be established in accordance with the standards of the Bruce Trail Association and should be covered with gravel or wood chips to support the natural setting of the proposed end use.
- An End Use Master Plan should be developed for implementation of the proposed end use by a Steering Committee representing the following agencies and interest groups:
  - Glenridge Landfill Liaison Committee (G.L.L.C.)
  - Glenridge Landfill Citizens' Committee (G.L.C.C.)
  - Shaver Hospital and other institutional/commercial establishments in the immediate area
  - Bruce Trail Association
  - City of St. Catharines

- Niagara Escarpment Commission
- Regional Municipality of Niagara
- Niagara Peninsula Conservation Authority (N.P.C.A.)
- Ministry of the Environment
- Ministry of Natural Resources (M.N.R.)

- The End Use Master Plan should be developed within two years of the issuance of the Certificate of Approval for the Grade Modification Proposal so that completed areas of waste disposal are progressively rehabilitated in accordance with a landscaping plan and end use.

End Use Master Plan

The End Use Master Plan was developed with input from the End Use Master Plan Steering Committee. Condition 15.7 of the Certificate of Approval required an End Use Master Plan Steering Committee to be established.

Condition 15.7 states the following:

> *"The City shall establish an End Use Master Plan Steering Committee within six months of the issuance of this Certificate to assist the City in finalizing the End Use Master Plan. The End Use Concept Plan described in Item 13, Schedule "A" shall be used to guide the Steering Committee in preparing and finalizing the End Use Master Plan. Membership for the Steering Committee shall be solicited from representatives of the City, G.L.C.C., G.L.L.C., M.O.E., N.E.C., Shaver Hospital and other neighbours of the Landfill, and other public interest groups and government agencies."*

The first meeting of the End Use Master Plan Steering Committee was held on April 15, 1997. The Steering Committee was comprised of representatives from the City of St. Catharines, G.L.C.C., M.O.E., N.E.C., Shaver Hospital, Niagara Bruce Trail Club, Regional Niagara, Brock University, G.L.L.C., the public, and public and government review agencies.

The draft Terms of Reference for the Committee were reviewed and accepted at the first meeting of the Steering Committee. The following summarizes the goal and objectives of the Steering Committee:

Goal

The goal of the End Use Master Plan Steering Committee is to assist the City of St. Catharines in preparing the End Use Master Plan to progressively rehabilitate the Landfill to a passive natural state with a trail system.

Objectives

The objective of the End Use Master Plan Steering Committee is to assist in the preparation and review of the End Use Master Plan with the following components:

- a Landfill Landscape Plan detailing species, age (i.e. size), placement and planting schedule for vegetation;
- identification of public safety features such as the need for lighting, fencing, and set-backs from restricted areas;
- determination of location and nature of walking trails;
- determination of accessibility requirements such as the need for fencing, gates, and parking areas, and the need for and extent of wheelchair accessible trails;
- determination of the extent of signage including trail markings;
- determination of the need for existing Landfill facilities including but not limited to the: After Hours Container Station, Leaf and Yard Waste Compost Facility, Storage Building/Garage, Portable Scale System and Scale House;
- preparation of an implementation schedule and costs for the End Use Master Plan; and

- protection of existing and proposed maintenance, monitoring or operational facilities including but not limited to the: Landfill Gas Collection and Flaring System Fanhouse and Flare, monitoring network, dechlorination system, Large Clay Borrow Pit Pond, Stormwater Management Systems, Secondary Landfill Entrance, Odour Control Facility, Groundwater Collection Trench and Leachate Collection System/Main Effluent Sewer.

A site tour of the Glenridge Quarry Landfill Site was conducted on May 21, 1997 to allow the members of the End Use Master Plan Steering Committee an opportunity to visit the Landfill and provide input on the end use of the Glenridge Quarry Landfill Site.

Three additional meetings were held by the Steering Committee to review and provide recommendations on the development of the End Use Master Plan.

PUBLIC CONSULTATION

An extensive public consultation program was established at the commencement of the process to ensure that the public and interested parties had opportunities to provide recommendations and review documentation. Figure 1 summarizes the public consultation program implemented.

Glenridge Landfill Liaison Committee

The Glenridge Landfill Liaison Committee (G.L.L.C.) was established in 1989 by the City to provide a forum to discuss issues related to operations at the Glenridge Quarry Landfill Site with citizens and neighbours of the landfill site. The committee includes representation from the M.O.E., N.E.C., the City, the adjacent City of Thorold, the Regional Municipality of Niagara, commercial and institutional establishments in the vicinity of the landfill site, Ward Councillors and the Mayor from the City and the G.L.C.C.

Members of the G.L.L.C. reviewed the drafts of the End Use Master Plan and discussed recommendations for end use development at the scheduled meetings of the G.L.L.C.

Glenridge Landfill Citizens' Committee

The Glenridge Landfill Citizens' Committee (G.L.C.C.) was formally established in March 1984 by residents north of the Landfill who became aware of the City's plan at that time to extend the life of the Glenridge Quarry Landfill Site. The G.L.C.C. is the only organized citizens group concerned exclusively with the Glenridge Quarry Landfill Site. The G.L.C.C. is comprised of residents who live in the vicinity of the Landfill.

Members of the G.L.C.C. attended all of the meetings of the End Use Master Plan Steering Committee, reviewed supporting information and provided comments on the drafts of the End Use Master Plan. The G.L.C.C. are supportive of the recommendations of the End Use Master Plan.

Public Open House

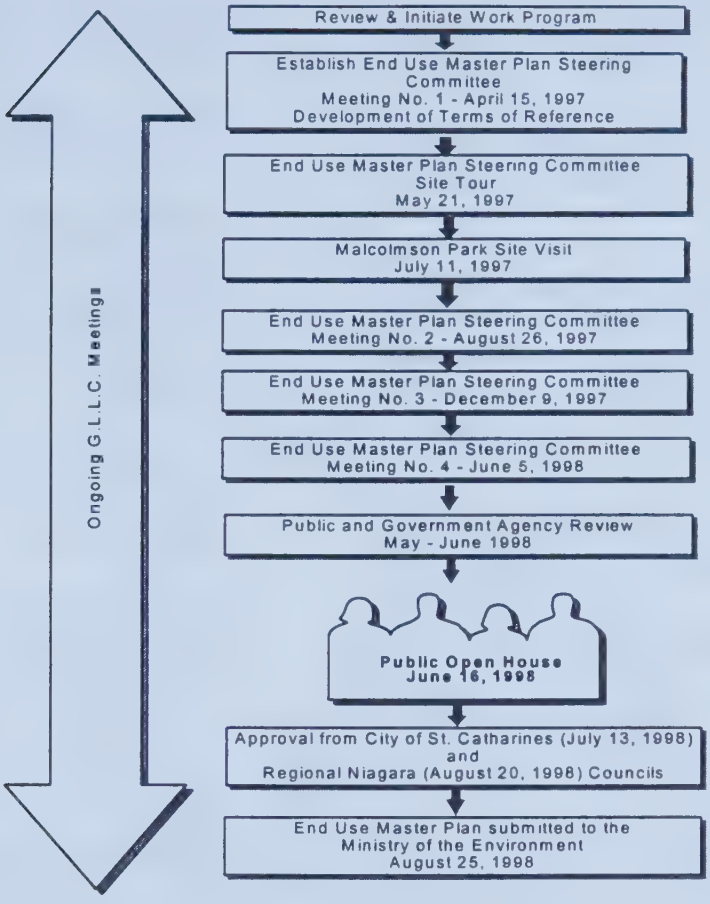
A Public Open House was held on June 16, 1998. The purpose of the Public Open House was to provide an opportunity for the public to review the details of the draft End Use Master Plan, ask questions and make recommendations. The Public Open House was held in the Regional Municipality of Niagara Administration Building across from the Glenridge Quarry Landfill Site.

An advertisement for the Public Open House and an article describing the End Use Master Plan appeared in the local newspapers.

RECOMMENDATIONS OF THE END USE MASTER PLAN

The recommendations of the End Use Master Plan are as follows:

Figure 1: Summary of End Use Master Plan Public Consultation



Approvals

- An application for Section 46 approval be submitted to the M.O.E. once landfilling operations cease. The final End Use Master Plan will be submitted to the Minister as supporting documentation for the Section 46 approval.

- The City prepare an application for a Development Permit considering the development objectives for the Urban Area and Escarpment Natural Area designations and the development criteria in the Niagara Escarpment Plan once landfilling ceases.

- The City consider seeking approval from the M.O.E. and other approval agencies to outlet stormwater into a natural watercourse when landfilling ceases and the waste disposal fill area is capped with final cover material.

- An application will be made to the Ministry of Transportation to receive permanent approval to permit the service entrance once landfilling ceases.

Public Consultation

- If major changes are proposed following M.O.E. approval of the Plan that are not consistent with the general intent of the End Use Master Plan, an amendment to the Plan will be required that includes a public participation program. Any amendments to the End Use Master Plan would need to be approved by the M.O.E., N.E.C., G.L.L.C. and both Councils of the City of St. Catharines and Regional Niagara prior to the amendments being implemented.

Implementation of End Use Master Plan

- The waste disposal fill area be progressively rehabilitated.

- The Glenridge Quarry Landfill Site be revegetated with a variety of vegetation types that are native to the area.

- A new Leaf and Yard Waste Compost Facility be constructed at the Landfill in 1998. The last date to receive leaf and yard waste at the facility is July 1, 2001 so that finished compost will be produced by December 31, 2001.

- The Leaf and Yard Waste Compost Facility close on December 31, 2001 and be rehabilitated in accordance with the End Use Master Plan.

- The After Hours Container Station be converted into a parking area.

- The existing lighting provided in the After Hours Container Station be maintained for the parking area to be established in this location.

- The existing fence located along the eastern and southern boundaries of the After Hours Container Station be removed.

- The area where the roll-off containers are located within the After Hours Container Station be backfilled and vegetated.

- The Portable Scale System be removed following closure of the Landfill.

- The Scale House be removed following closure of the Landfill.

- The existing chain link fence along the southern and southwestern property boundaries be removed.

- The existing gate at the main entrance to the Landfill be removed and replaced with a lockable swing gate on the road immediately north of the present location of the Scale House. The lockable gate will be maintained at the secondary entrance.

- A series of trails be incorporated into the End Use Master Plan.

- Information signs be located at the entrances to the Naturalization Site (main vehicle entrance, access from Bruce Trail and access from the proposed connection to the adjacent institutions at the northwest corner of the property).

- Two scenic lookouts be established at the highest elevation of the former waste disposal fill area.

- Seating areas be located at discrete locations around the Large Clay Borrow Pit Pond and at the proposed lookouts at the highest elevation of the former waste disposal fill area. Benches be located at the front entrance of the Naturalization Site.

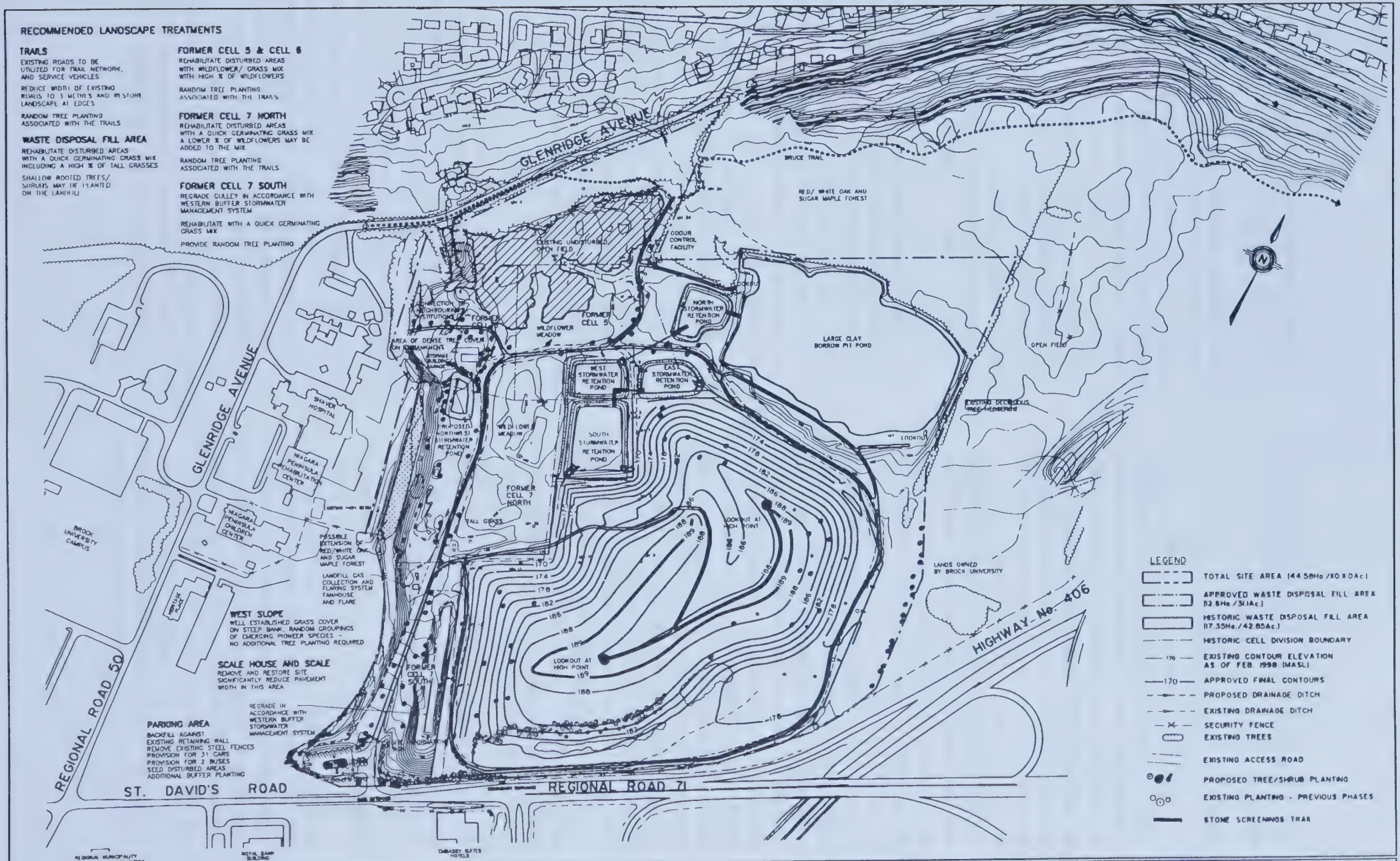
- Waste containers be placed at the front entrance of the Naturalization Site.

- A pet litter bag dispenser (e.g. stoop n' scoop) be provided by the proposed parking area.

- The Storage Building/Garage remain subject to a review as part of the development of the Final Closure Plan for the site.

- Once Section 46 approval is received, public access be permitted at the former Glenridge Quarry Landfill Site. Until such time, public access will be prohibited.

The End Use Master Plan is illustrated on Map 2.



Approved

City of St. Catharines

GLENRIDGE QUARRY LANDFILL SITE
END USE MASTER PLAN

LANDFILL LANDSCAPE PLAN

PROCTOR & REDFERN LIMITED
Professional Consulting Services

Scale 1:2000

MAP 2

DETAILS OF THE END USE MASTER PLAN

Trails

The End Use Master Plan includes a series of trails. To maintain the natural setting of the proposed end use, it is proposed that none of the trails be paved. Stone screenings will be used on all trails. The proposed trail network will connect with the Bruce Trail and may connect to the neighbouring institutions to the west.

Considering that all proposed trails will link with the Bruce Trail, it is proposed that all trails be constructed in a manner compatible with the Bruce Trail.

The trails will be pedestrian oriented and use by motorized bicycles, bicycles and horses will be discouraged. The Landfill is being developed as a Naturalization Site and has a number of potential hazards (i.e. steep slopes, uneven terrain). In the interest of public safety for all trail users and to avoid damage to the infrastructure and the vegetation, it is recommended that the trails be restricted to pedestrian and wheelchair use only. Signs will be posted at the main entrance to the Naturalization Site and connections from the off-site trails stating that users must stay on the trails because of the potential hazards that may exist off the trails.

The primary trail around the waste disposal fill area will allow access to the site for the purposes of maintenance and monitoring.

Vegetation

It is proposed that the Glenridge Quarry Landfill Site be revegetated with a variety of vegetation types that are native to the area. The vegetation layout has been developed in consultation with the G.L.C.C., N.E.C., N.P.C.A. and M.N.R.

A large portion of the buffer area has already been vegetated. It is recommended that the following areas be rehabilitated in accordance with the following recommendations:

Large portions of Former Cells 5 and 6 have an established vegetative cover. However, those areas that are currently disturbed will be rehabilitated with a wildflower mix. An example of a typical wildflower mix is as follows:

- Mustang Tall Fescue
- Spartan Hard Fescue
- Strawberry Clover
- variety of wildflowers (Iceland Poppy, Blue Flax, Lupine Perennial, Calendula, Blanketflower, Yarrow, Purple Prairie Clover, Lance-Leaf Coreopsis, Black-Eyed Susan, Everlasting Pea, Prairie Coneflower, Blazing Star, Baby's Breath, Snapdragon, Bachelor Button, Wall Flower).

The Fescues are a non-competitive seed which germinates relatively quickly and provides a grass cover to stabilize the area until the wildflowers become established.

Some tree planting is recommended in this area to provide shade and to reduce the scale of this very large open space. Groupings of native trees and shrubs should be planted in a natural and random pattern in association with the trail system.

The rehabilitation of Former Cell 7 South includes some filling in the long deep gully located between the main entrance road and the base of the Landfill in the southwest portion of the property as shown on Map 2.

Rehabilitation of Former Cell 7 South includes:

- importation of clean fill and rough grading to the new contours required
- placement of suitable planting material, spread 100 mm deep and fine grading
- establishing a grass cover of White Clover, Fiesta Perennial Ryegrass, Forage Tall Fescue, Creeping Red Fescue, Victory

Chewings Fescue, Timothy and Kentucky Bluegrass.
- planting random groupings of trees and shrubs on the level areas and in association with the proposed trails.

The northern portion of Former Cell 7 North may be rehabilitated as a variation of the wildflower meadow concept. The southern portion of Former Cell 7 North will be rehabilitated with a Tall Grass mix.

Tree planting in association with the trail system could also be an enhancement in the Former Cell 7 area.

A recommendation of the End Use Master Plan is to develop a parking area where the After Hours Container Station is currently located as shown on Map 2. The elements of the landscape rehabilitation plan for the parking area as follows:

- importation of clean fill, placement of suitable planting material, fine grading and seeding the area where the roll-off containers are currently located
- removal of the existing fences
- planting groupings of trees and shrubs to improve the aesthetics of the proposed parking area and the main entrance to the Naturalization Site

Condition 15.5 requires that as soon as feasible or at maximum within six months after any part of the waste disposal fill area has reached its approved limits, final cover of at least 0.75 metres thick shall be applied and compacted in accordance with good landfill practices. There shall be a minimum of 0.15 metres of suitable planting material placed over the final cover and these areas shall be seeded within one year of placement of suitable planting material as weather and growing conditions permit.

It is recommended that the vegetation on the waste disposal fill area be enhanced. An example of a typical grass mix is as follows:

- White Clover
- Fiesta Perennial Ryegrass
- Forage Tall Fescue
- Creeping Red Fescue
- Victory Chewings Fescue
- Timothy
- Crest Perennial Ryegrass

This seed mix is recommended for areas where a rapid cover and roots for stabilization are required.

Other vegetation may also be considered for the rehabilitation of the waste disposal fill area (i.e. oats).

The planting of random groupings of shrubs and trees is also recommended so that this large and open landform will have a more natural appearance and blend with the surrounding landscape. Objectives of the plant material are to reduce the scale of the Landfill and to provide some shade along the trails without blocking views from the scenic lookouts at the top of the Landfill. The recommended species will depend on the thickness of suitable planting material provided and tolerance to difficult growing conditions including lack of water during the summer months, exposure to harsh winds and minimum maintenance.

Other seed mixes that could be used are Crown Vetch and Birdsfoot Trefoil. Crown Vetch is deep rooting, hardy and produces masses of thick vegetation with pink/purple flowers. It can be difficult to establish but then spreads quickly to stabilize banks. Birdsfoot Trefoil is deep rooting, winter hardy and produces a yellow flower. It is easy to establish and spreads quickly to stabilize banks.

Potential locations include disturbed embankments on the west side of the property, the slopes of the deep gully, any ponds and ditches developed as part of the Western Buffer Stormwater Management System or the side slopes of the proposed connection from neighbouring institutions.

Test Plantings/Seed Harvesting and Exchange

Because of the size of the site and the variety of vegetation types identified in the Landfill Landscape Plan included in the End Use Master Plan, there will be ample opportunity to carry out test plantings of species. Furthermore, the inclusion of large wildflower areas in the Landfill Landscape Plan will allow the opportunity to participate in seed harvesting and exchange programs with other naturalization projects.

Accessories

Seating areas will be located in discrete areas around the Large Clay Borrow Pit Pond and at the proposed lookouts to be established at the highest elevation of the former waste disposal fill area. Suggestions for seating include large rocks from the former quarry and fallen tree trunks in keeping with the naturalization of the Landfill. Benches will be located at the front entrance of the Naturalization Site.

Waste containers will be placed by the proposed parking area for ease of servicing.

A **pet litter bag dispenser** (e.g. stoop n' scoop) will be provided by the proposed parking area.

Two **scenic lookouts** will be established at the highest elevation of the former waste disposal fill area. Considering the proximity of the Niagara Escarpment, the viewshed from these lookouts will be significant. One lookout will be established in the area of former Cell C to permit views of the Large Clay Borrow Pit Pond. The second lookout will be located on the former Interim Use Cell to take advantage of the impressive vista of St. Catharines, Lake Ontario and the Toronto Skyline.

At the northwest corner of the property, a **wheelchair accessible connection** is proposed from the quarry floor to the institutional uses located west of the Landfill. A trail will be located from this connection to the perimeter trail. Additional access to the Bruce Trail from the top of the connection will be through the Hospital property.

Information/Interpretative Signs will be located at the entrances to the Glenridge Quarry Naturalization Site (main vehicle entrance, access from Bruce Trail and access from the proposed connection to the institutions at the northwest corner of the property). The signs will provide information on the history of the site, a trail map, identification of plant and wildlife species and the rules for site users.

Partnerships

As the End Use Master Plan is being implemented at the Landfill, partnerships with other parties will be explored. For example, the City may wish to partner with the local District School Boards to establish outdoor education programs at the site or to have students build birdhouses or signs. Partnerships with local community groups may result in cost-sharing of some of the revegetation initiatives at the site, for example, tree planting.

SUMMARY

The End Use Master Plan for the Glenridge Quarry Landfill Site was approved by the City of St. Catharines Council of July 13, 1998 and Regional Niagara Council on August 20, 1998. The formal submission was made to the M.O.E. on August 25, 1998.

The Landfill is currently being progressively rehabilitated as areas of the waste disposal fill area achieve final contours according to the End Use Master Plan.

The progress of the implementation of the End Use Master Plan will be documented in the Annual Reports submitted to the M.O.E. and the G.L.L.C. The success of the End Use Master Plan will also be documented in the Annual Reports following receipt of Section 46 approval from the M.O.E. and the use of the Naturalization Site by the public.

MITIGATING IMPACTS OF SEWER CONSTRUCTION THROUGH WETLAND RESTORATION AND HABITAT CREATION: THE DEVIL'S CREEK TRUNK SEWER PROJECT

J. Arnel Fausto, Sarah K. Mainguy, and Eckhard C. Pastrik

CH2M Gore & Storrie Limited, Waterloo, Ontario

and

Kirit Patel and Fabian Bandoni

Corporation of the City of Cambridge, Cambridge, Ontario

ABSTRACT

In Canada, one of the major challenges associated with infrastructure development has been the need to maintain a balance between planned urban growth and expansion of services without compromising the commitment to protection of significant environmental features. With technologically advanced construction techniques, ecologically sustainable solutions with minimal impacts to environmental features are now more feasible economically and technically. For example, the Devil's Creek trunk sewer project was a sewer construction project that gradually evolved into a major ecological enhancement and restoration endeavour that persisted despite seemingly insurmountable constraints. The Devil's Creek project is the first Canadian microtunnelling application and sewer construction project to cross a provincially protected significant wetland and a regional environmentally sensitive area with full approval from all levels of government.

The Devil's Creek Valley is composed of a wetland and adjacent mature growth forest that is well-recognized for its size, quality, and rare species it supports. Its many significant features include a natural cold-water trout fishery and provincially significant plants and wildlife. Despite the need to protect the valley's natural features and functions, planning studies conducted as early as the 1970s indicated a need for sanitary sewer servicing to accommodate growth at Cambridge's west end. The most attractive alternative available in terms of minimizing cost, maintenance, and social disruption was a gravity sewer line along the natural valley system, with a potentially significant impact to the environment.

This paper presents the restoration measures used to reduce the level of impact from gravity sewer construction through 1.3 km of construction easement. A combination of restoration techniques and the results of two years of post-construction monitoring are presented to provide insight on the application of restoration measures for similar projects.

Introduction

The Devil's Creek Valley is situated along the west side of the City of Cambridge (population approximately 100,000) located 100 km west of Toronto, in an agricultural area of Ontario. The valley is comprised of a large 100-acre wetland and adjacent upland mature growth forest, which have undergone a minimal degree of human disturbance in the past. The valley is renowned for its flora and fauna occurring in a relatively pristine environment within the city limits. Because of these attributes, the area was designated as a provincially significant wetland and an environmentally sensitive policy area by both regional and provincial planning authorities. The

City of Cambridge is committed to protecting the wetland from the cumulative effects of development and human encroachment.

While the City of Cambridge owns a great deal of the property encompassed by the wetland, a significant portion of the remaining woodland and smaller wetlands are owned privately. Many of these private lands are currently undergoing development. The city's west end was experiencing rapid growth, placing a huge demand for sanitary sewer services. Development was also threatening to affect adjacent lands that are integral to the future sustainability of the wetland ecosystem. Much of the original hardwood forest that once lined the Devil's Creek Valley has been cleared, resulting in fragmentation. Along its remaining wetland communities, signs of urban encroachment are evident.

The location of the Devil's Creek Valley and the valley's floral and faunal attributes are shown on Figure 1.

The Need for Sanitary Sewer Servicing in the City of Cambridge

Because of increasing development pressure associated with westward expansion of the City, the need for sanitary sewer servicing was the primary constraint in limiting growth.

An aging pumping station, constructed as a temporary facility in 1967, had failed in one instance, resulting in a bypass of raw sewage to Devil's Creek. With this system in need of replacement, the only other alternatives were to construct a gravity sewer down a valley parallel to and crossing Devil's Creek at various points, including the wetland, or to pump the wastewater out with new or rebuilt pumping stations. Construction through city streets would incur major associated capital and continual operating costs.

When construction through the Devil's Creek Valley was presented as a feasible alternative, the potential impacts to the provincially significant and environmentally sensitive area became a controversy among local government agencies, public interest groups, and concerned citizens. These parties had to be satisfied that no long-term ecological damage to the valley would occur. The proposed sewer line could not change the wetland's water table, destroy mature woodlands, reduce wetland or function area, or disturb the habitat of endangered creatures. The planning process for the Devil's Creek project stretched from four months to four years because of public opposition, environmental restrictions and constraints placed on the project, and changing provincial legislation during the process (i.e. the Ministry of Natural Resources' Wetland Policy was enacted during the project).

Evaluating Alternatives

In accommodating the demand for future growth, the City of Cambridge and CH2M Gore & Storrie Limited, the project consultant, examined a number of servicing alternatives in great detail. These alternatives included two different pumping scenarios along city streets, each with a new pumping station or a gravity sewer. This evaluation indicated that all available options to upgrade existing infrastructure were costly in terms of construction as well as increased maintenance and risk of potential failure in the long term. The most attractive solution was the gravity sewer line along the natural valley system, but this option presented a potentially significant impact to the environment.

Three different scenarios for gravity sewer servicing were examined. The first involved a combination of open-cut and microtunnelled sections under a sensitive wetland and stream crossing. The second scenario was the worst-case variant of this approach assuming that the microtunnelling equipment could not be advanced due to an in situ obstruction, requiring it to be excavated and retrieved. The third approach involved an open-cut method with all efforts to minimize the extent of disturbance.

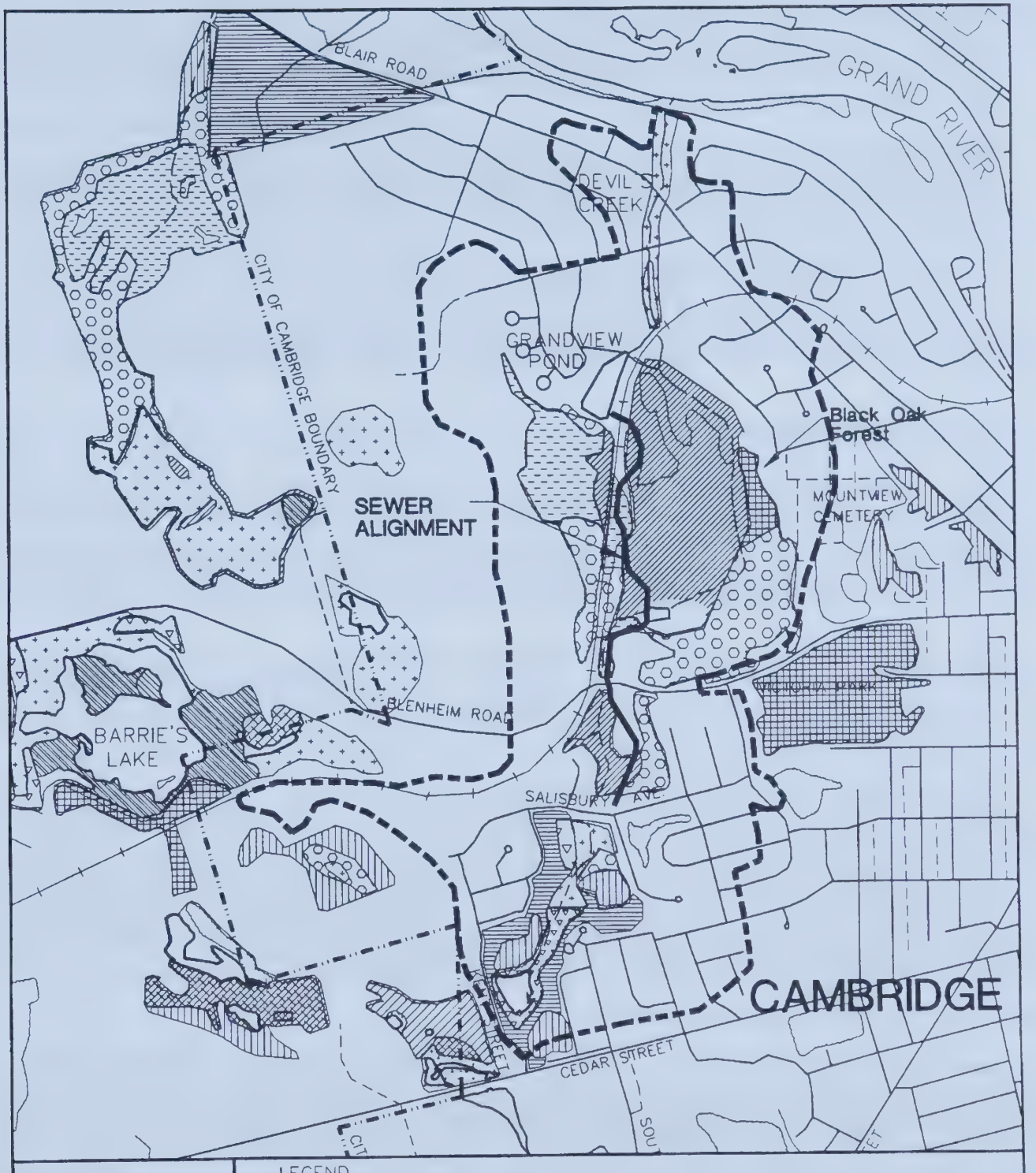


Figure 1

PLAN VIEW OF SANITARY SEWER ALIGNMENT THROUGH DEVIL'S CREEK WATERSHED

The main differences among the alternatives were:

- The extent of habitat disturbance and potential loss to the wetland for the open-cut sewer, which ranged from 0.0 ha (pumping) to 0.53 ha

- The uncertainty that microtunnelling posed. Microtunnelling could reduce ecological damage, but the nature of the geological materials (gravels, tills) meant that there was a risk of having to excavate and retrieve the tunnelling equipment, causing significant damage

- The major cost differences – from $1.6 million to $3.0 million

Because of the strong views generated by the public and agencies against any loss of ecological features, an integrated strategy was developed, which neutralized opposition to the project and led to acceptance by all stakeholders.

The Preferred Alternative

The gravity sewer method was recommended as the preferred alternative, if steps were taken to minimize all possible environmental risks, from an operational and cost perspective. If the environment could be further improved with cost savings realized from this project (i.e. savings realized by constructing a gravity sewer instead of the more expensive pumping station), the chances of gaining public acceptance and agency approval were greater. The gravity sewer approach required approximately 1,500 m of 750-mm diameter sewer.

The city believed that a minor intrusion through the least sensitive and most disturbed portion of the valley parallel to an existing railway line and along an existing horse trail could be approved if the construction/ restoration plan could demonstrate no long-term impact to the wetland would occur and if the project could significantly improve the existing area over time.

Part of the savings that were accrued from choosing the gravity sewer method instead of the pumping station alternative were specifically set aside for environmental restoration and enhancement on a watershed scale. This $550,000 budget was established by Cambridge City Council to ensure the long-term viability of the Devil's Creek Valley following inevitable development after the construction and hookup of the sanitary sewer. Some of these funds (approximately $200,000) were used in 1996 to acquire private properties, which enhanced the important hydrological and biological connections beyond the immediate area impacted by sewer construction. The balance of the budget was to be spent on a watershed ecological enhancement program.

Easement Construction and Restoration Plan

A restoration plan was developed to address impacts from construction at the site level. The objective of the plan was to ensure that the habitat area affected by construction was retained as close to its original state as possible (with no net loss in habitat) and to enhance it by creating new habitat for wildlife.

In the development of the best routing for the sewer, all stakeholders from both government agencies and the general public were asked to indicate the location that would minimize their concerns, based on an ecological study of the wetland area. The composite route that was identified meandered around most of the sensitive wetland features (Figure 2). For this project, the usual "straight line" approach for engineering projects of this type was abandoned.

Ecological damage to the wetland was kept to a minimum by routing the line around significant flora and fauna and scheduling construction to avoid sensitive periods of the year.

The composite route was 20 percent greater in length and would disturb 21 percent less natural habitat than a comparable straight-line route, which had been recommended in an earlier engineering study. By scheduling construction during the winter, impacts to the wetland were minimized.

Vegetation Communities Before Construction

Vegetation along most of the proposed sewer route was classified as swamp (i.e. wooded wetland). A major portion of the route was dominated by wetland shrubs such as shining and pussy willow (*Salix lucida* and *S. disidor*, respectively) and red-osier and gray dogwoods (*Cornus stolonifera* and *C. racemosa*). Other parts were dominated by wetland trees such as hybrid willow (*Salix* x *rubens*), balsam poplar (*Populus balsamifera*), and elm (*Ulmus americana*). The understory was patchy, consisting of a variety of shrubs, herbs, and grass-like plants (graminoids), which were primarily native (76 percent). However, common and glossy buckthorn (*Rhamnus cathartica* and *R. frangula*, respectively) occurred abundantly throughout the swamp and formed a monoculture in some places.

A section at the south end of the route was vegetated by mature deciduous forest. At the north end of the deciduous forest, the route went through a pond with surrounding marsh vegetation, before proceeding through an adjacent sawmill (which was denuded of vegetation). This pond was degraded by deposition of sediments and heavy growths of green algae but, nonetheless, served as breeding habitat for yellow-spotted salamanders.

One other section was characterized as a transition zone between an area of successional upland vegetation and adjacent swamp. This area was cut to allow the sewer to pass and then filled and re-formed as a steeper slope after construction.

Wildlife Habitat Before Construction

The route was selected to follow existing openings along a horse trail, where bird species were typical of woodland edges and small patches of thicket or swamp — species that are ubiquitous in southern Ontario, such as Northern Cardinal, American Robin, and Rose-breasted Grosbeak. Mammals included species common of small woodlands or woodland edge, such as white-tailed deer and eastern chipmunk. Because little standing water was present along most of the route to provide breeding habitat for frogs and salamanders, few amphibian species existed. Breeding habitat for significant species of salamanders had been identified along some of the alternatives originally proposed for the sewer route. Amphibians noted along the route north of the deciduous forest were American toad and leopard frog. The pond at the north end of the deciduous forest provided breeding habitat for mole salamanders, though not the significant Jefferson's Complex salamanders, which were identified as a constraint along other alternative routes. The only reptiles noted were snapping and painted turtles.

Construction Methods

The preferred construction method consisted of closely regulated open-cut trench construction along the disturbed wetland portions of the route and trenchless microtunnelling through more sensitive areas, such as the deciduous forest.

The open-cut trench used a minimal construction easement width of no more than 11 m to allow for trench, spoil pile, and equipment movement along a vehicular access road beside the excavation. This easement was pinched in to approximately 6 m in specific areas to avoid specific features. It also required a few wider turning points along the route and an offsite storage area. By controlling all vehicular and construction width through this easement area, the area disturbed was minimized.

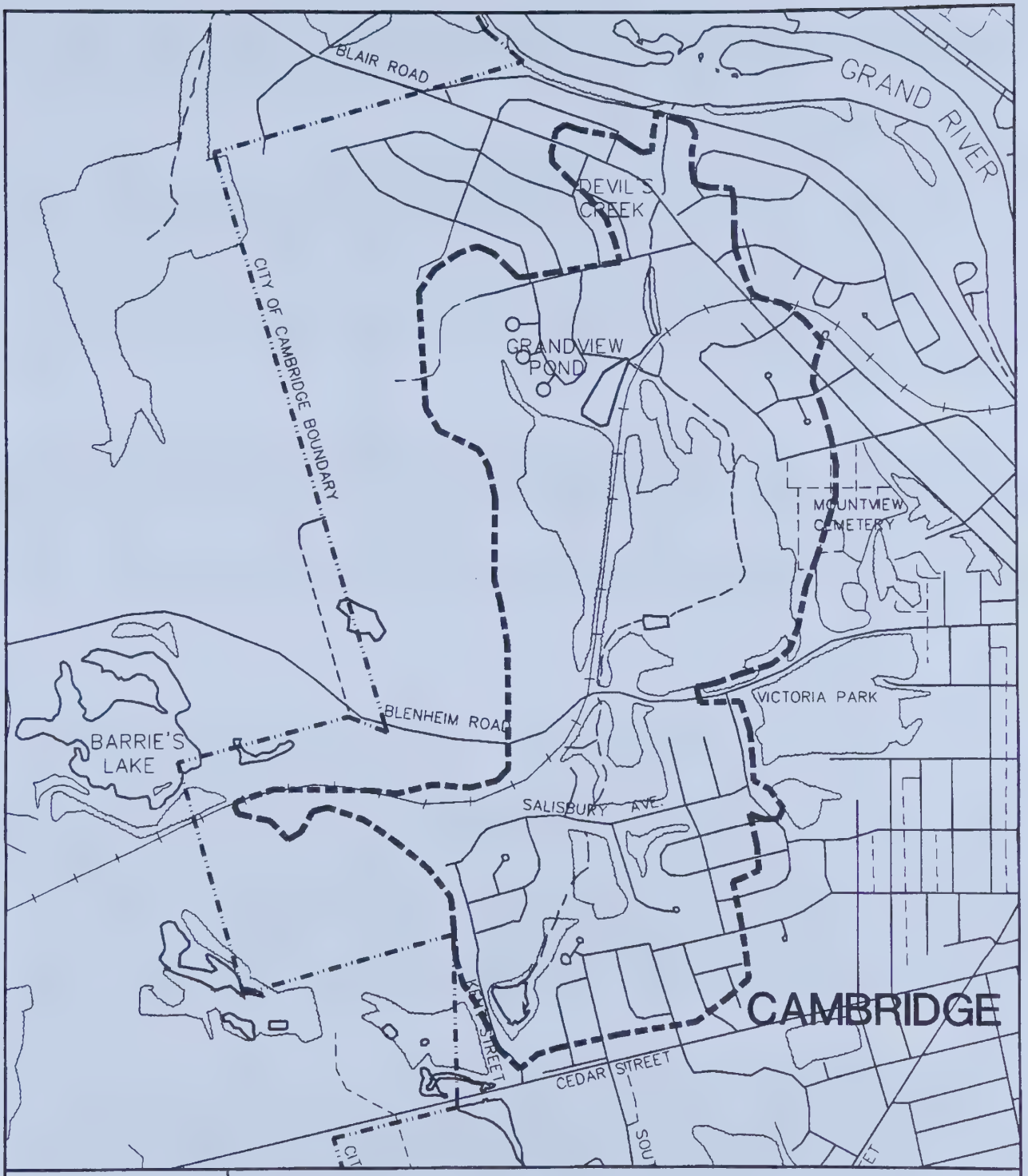


Figure 2

LOCATION OF THE DEVIL'S CREEK WATERSHED IN THE CITY OF CAMBRIDGE AND SIGNIFICANT SPECIES AND PLANT COMMUNITIES

LEGEND

SIGNIFICANT SPECIES

K1–5 Ambystoma Salamander 1991–1995
2 Smooth Soloman's Seal
3 Smartweed
4 Fringed Gentian
5 Hemlock Parsley
6 Black Mountain Rice
7 Clearweed
8 Thin-leaved Sedge
9 Golden Alexander
10 Pignut Hickory
11 Hill's Oak(tentative location)
12 Blue-leaved Willow
13 Hairy-fruited Sedge (widespread in fen)
14 Area-sensitive Bird Species
15 Necklace Sedge
16 Arrow-leaved Tearthumb
17 Water Shield (widespread in open water marsh)
18 Olive Spike-rush (widespread in fen)
19 Hard-stemmed bulrush (widespread in fen)
20 Water Dock
21 Carpenter's Square Figwort
22 Significant Marsh Bird Species
A1–A4 Ambystoma Salamander location only (1995)

SIGNIFICANT COMMUNITIES

Open Black Oak Forest
Leatherleaf/Carex Lasiocarpa Fen

Devil's Creek Subwatershed Boundary

SOURCE: (BASE) Ministry of Natural Resources Survey's and Mapping Branch, Ontario Base Map, 1983.

0 100 200 300 400 500
METRES

The use of high-strength pipe during construction was beneficial because it eliminated the need for bedding materials (i.e. clear stone) along the entire trench for pipe support. This pipe reduced material handling requirements and avoided the risk of lowering the natural water table through longitudinal water migration along the pipe.

Before the open-cut excavation, biologists conducted a detailed botanical survey of the construction easement. Plugs of significant plant material were identified for transplanting and saving. Native seed material was collected from plants indigenous to the wetland. During the winter construction period, this native plant material was grown and cultivated in a greenhouse for easement restoration in the spring. The remaining plant material along the easement was cut close to the ground surface in preparation for open-cut construction.

After vegetation was cleared along the easement, the area was intentionally made unattractive to wildlife by removing various cover materials. Herbaceous flora on one side of the easement was covered with geotextile cover, which was used as a base for the gravel roadway for construction vehicles. The use of geotextile cover allowed for optimum protection during construction.

During construction, topsoil was stripped from the subsoil and stockpiled separately. As sections of pipe were laid along the trench, soil was put back in the order that it was excavated. Excess soil was trucked offsite. This activity ensured that the characteristics of the original soil properties both physically and chemically were retained, which preserved the natural seedbank and reduced the chances of invasive plant species recolonizing the site. Upon grading the original topsoil material, entire soil plugs containing plant material were returned to their general locations.

Groundwater levels were closely monitored throughout the initial phases of construction to ensure that the new sewer line did not alter the water table and change the hydrological regime of the wetland.

During open-cut trench construction, sediment runoff was controlled by constructing large sedimentation ponds along the easement to control the large amount of silt-laden water generated. Because silt was considered detrimental to the sensitive wetland and cold fisheries habitat in the area, great care was exercised in controlling the extent of siltation as much as possible. In addition to constructing ponds along the easement, the newly constructed sewer line sections were used as a conduit to an offsite sedimentation pond. These ponds were then converted to amphibian habitat after construction.

Microtunnelling was used in sections of mature woodland and to cross a rail embankment without disruption to the active rail services. The main disadvantage of this technique was the cost, which exceeded $2,100 per metre, including jacking and exit pits. In contrast, the cost for the open-cut method was $750 per metre, which included pipe.

Approximately three-quarters of the open-cut work was completed by late February 1996 before microtunnelling was used on the remaining segments. In total, three microtunnelling drives were completed: the first bored a length of 32 m beneath a railway embankment through silty sand and cobbles. The second drive was through a 144-m section beneath a creek bed and deciduous forest through silty sand and sandy clay. This section was considerably more difficult because of the length and small boulders within the sand layers. The final drive was completed through a 39-m section of wet sand under a highway embankment.

Easement Restoration

After construction, the trees and shrubs were planted in the replaced soils suitable for the post-construction soils and moisture regimes along the top of the sewer trench. The 4-m vehicular access road was left and not revegetated because of the possibility that a trail might be approved along its length. Trees and shrubs were chosen for planting because of the concern that non-native plants might invade the disturbed soils. Initially, the

wetland portions of the route were planted as quickly as possible in the early spring with cuttings from the adjacent shrub swamp, mainly red-osier dogwood and shrub willows. The cuttings were taken in March, before the shrubs had leafed out. Plugs of herbaceous wetland plants were removed from the adjoining wetland and planted along the route.

The transition area between upland and wetland, which was cut and re-formed as a steep slope after construction (one of the few areas of upland soils along the route), was also planted with trees and shrubs, in order to limit the growth of non-native plants. The deciduous forest at the south end of the route was not significantly affected, because the sewer route was tunnelled underneath, and planting was concentrated mainly around the transition area between the pond and the forest. The few impacts in this area resulted from fears of liability: a few large beech trees along the easement showed signs of mortality and were cut down by the City of Cambridge. One of these trees may have been killed by tunnelling, others were already dead.

Intrusion of invasive weed species was kept to a minimum partly by the establishment of the newly planted ground cover and controlled by chemical and physical means at the construction entry point at the wetland periphery. Remaining exposed soils in drier portions of the easement were seeded with an annual rye ground cover, which acted as "nurse crop" for the native herbaceous material in the forthcoming seasons.

Following the establishment of plant material, amphibian habitat was created from sedimentation ponds that were used during construction. Concept plans for three ponds aimed at target amphibian species, such as rare salamanders and frogs, were designed based on specific habitat requirements. The remaining wetland plant material that was propagated specifically for pond use was used to create a natural-looking littoral zone in each habitat.

Pond Reconstruction

The pond was reconstructed from a shallow marsh community to a permanent pond to deepen and improve its water retention and to exclude fish species, which could prey on salamander eggs or larvae. The transition from upland to wetland around the pond between the sawmill and the deciduous forest is more abrupt than prior to construction because of difficulties associated with maintaining a reasonable depth in such a small area. In addition, the topsoil and subsoil separation south of the pond was poor. The pond edges were planted mainly with adaptable tree and shrub species characteristic of transition zones between upland and wetland, such as eastern cottonwood (*Populus deltoides*) and nannyberry (*Viburnum lentago*). These species have generally survived, but there has been some influx of non-native species in the area. There is very little growth in the area where subsoil and topsoil were mixed.

Post-Construction Vegetation Communities

The vegetation community along the proposed sewer route can still be classified as wetland, two years after construction and planting, but the type of wetland vegetation has changed somewhat. The success of the shrub planting was variable. The red-osier dogwood generally did not root as well as expected and is now found only in small quantities. The success of the willows was variable. However, herbaceous and grass-like plants from the seed bank in the stockpiled wetland soils and planted plugs, and possibly the seed rain from the adjacent wetland, have produced a dense mat of herbs, grasses, rushes, and sedges along the entire wetland portion of the route. Many shrub willows have germinated from cuttings but are overshadowed by other vegetation.

The dominant plants in any given portion of the route vary. Swamp aster (*Aster puniceus*), soft rush (*Juncus effusus*), cattail (*Typha angustifolia*), stinging nettle (*Urtica dioica* var. *procera*), black bulrush (*Scirpus atrovirens*), boneset (*Eupatorium perfoliatum*), and various sedges (*Carex vulpinoidea*, *Carex stipata*) are the most common dominants and occur in patches throughout the route. Along one small portion of the route, planted willows have become dense enough, though still small, to dominate other vegetation, which may be

related to the shade produced by trees that overhang both sides of the route in that location. Willows likely are more shade-tolerant than plants of open marshes. The patchiness of the vegetation appears to be determined mainly by subtle differences in the type and moisture of the soils along the route. The differences in microhabitat that were most obvious after construction were:

- variations in groundwater seepage and surface flows in different areas, caused mainly by impoundment by the access road

- variations in the separation of topsoil and subsoil along the route, with consequent variations in soil fertility and drainage

In some areas along the route, plants usually associated with drier soils, such as tall goldenrod (*Solidago altissima*), are almost as common as plants more traditionally associated with wetlands, indicating that some parts of the route may become classified as upland as vegetation dynamics proceed.

Non-Native Plant Invasion

The restored sewer route is dominated by native plants, except in one section where purple loosestrife (*Lythrum salicaria*) is one of the dominants, but it has not become a monoculture as in some wetlands. The loosestrife was already abundant in the soils of the immediate area; it was the dominant plant around an adjacent pond. Two other highly invasive non-native species common in the Devil's Creek wetland, common and glossy buckthorn, are found in one small area of the wetland portion of the restored route, where they can be controlled. These individual plants probably originated from roots or stems that were inadvertently left in the soils along the route during the restoration.

Post-Construction Wildlife

Breeding bird species noted in the monitoring survey two years after construction (1998) were essentially the same as had been noted in 1994 prior to construction. The Ovenbird, the only species noted in 1994 that is an indicator of forest interior habitat, was not noted in 1998 surveys. However, another species indicative of forest interior habitat, Scarlet Tanager, was noted in 1998. Two species of open marsh, Common Yellowthroat and Swamp Sparrow, have colonized the marsh habitat now found along the route. They were not noted in the swamp habitat that characterized the route prior to construction.

Mammal, reptile, and amphibian species along the restored route are also essentially the same as those noted in 1994. One "new" species of open marsh, chorus frog, was noted in the portion of the route primarily dominated by cattail. A pond created for amphibians along the route appears to be unsuitable for amphibian breeding because of heavy algal growth. However, this pond has the potential to improve as planted vegetation at its edge becomes taller and shades out the algae.

Approximately 15 breeding adult yellow-spotted salamanders were noted in 1997 and 1998 spring surveys in the reconstructed pond at the north end of the deciduous forest. Though these numbers have never been seen before in this pond, they must have always been there, because this type of salamander is generally faithful to prior breeding habitat. The present configuration of the pond likely allows the salamanders to be seen more easily. Bullfrogs, green frogs, and small fish have been noted in the reconstructed pond and, because these can be predaceous species known to prey on salamander eggs and larvae, it is not certain whether this habitat is now a "source" or a "sink" for these salamanders.

Summary and Concluding Comments

Results from the project during the first and second years were largely successful as evidenced by the rapid regrowth of vegetation and re-colonization of the disturbed area by wildlife. Evidence of the disturbance through open-cut construction has largely been diminished, although the access road is still evident. This road is likely to be modified or removed, pending the decision on the trail. Except for the mortality of one tree that was close to the tunnelling shaft, no changes in the vegetation community in the microtunnelled portions of the route have occurred. Groundwater monitoring showed no change in water level fluctuation before and after construction. Public involvement and support for the project has also increased, and plans are underway to develop the construction access road into a community trail.

Although public and agency skepticism of the project was initially high during the planning stages of the project, the care that was taken to ensure no damage to the wetland habitat and the habitat restoration effort instilled a greater amount of public acceptance for the project. Involvement by school groups, community volunteer organizations, and the local conservation authority helped to raise the profile of the project.

With the methods used (tunnelling in part, routing, and restoration), a consensus was reached by all parties on the preferred location, method of construction, and mitigation. The final cost of the project, which was $2.4 million (which included costs for numerous studies as well as construction) was substantially less than original cost estimates for replacement of pumping stations and existing sewer lines. Funding for the entire project was provided from development charge fees assessed by the municipality on all new development projects. The gravity sewer option was a superior engineering design because it followed the natural hydrological gradient of the valley terrain and this option was only possible through the use of recently developed technology, micro-tunnelling. The project also relied heavily on the understanding of ecosystem processes at the watershed and site-level scale to develop a plan for restoring disturbed areas to ensure retention of environmental characteristics and qualities of the former vegetative cover.

TOWARD A PREDICTIVE MODEL FOR NATURALISATION OF AGGREGATE PITS ON THE OAK RIDGES MORAINE

Ken Dance and Mark Browning

Dance Environmental Inc.
193 Lakeside Drive, Kitchener, ON N2M 4C7
Wildlife and Natural Heritage Science Section, Ministry of Natural Resources
P.O. Box 7000, Peterborough, ON K9J 8M5

ABSTRACT

A research study was designed to document the types of natural communities developing in aggregate sites on the Oak Ridges Moraine and to identify the critical factors for success in their establishment.

An initial list of known pit sites were grouped into two rehabilitation categories: deliberate rehabilitation or none; and two age categories: greater than 15 years old or less than 15 years old. Five replicate pits were randomly chosen from each rehabilitation and age combination and these twenty pits were studied during the 1997 growing season.

Physical and biological data were collected from six hundred quadrats. Vegetation, amphibians, and birds were quantitatively inventoried and occurrences of reptiles and mammals were noted. Site and rehabilitation history and the landscape context were also determined for each pit. Study plot histories range from those which had been rehabilitated within 2 years, to those which had been abandoned for more than 50 years.

Ordination of physical and site history data along with the plant species richness and density data identified key factors contributing to the establishment of different communities. A review of literature on site restoration, landscape ecology and conservation biology also contributed to identifying factors which facilitate successful site naturalisation.

This paper describes twelve factors which form the basis of a predictive model for naturalising pits on the Oak Ridges Moraine. Examples of such factors include: site size, history and topography, surface and ground water, soils, existing adjacent biological communities, social and economic factors.

Key steps for implementing pit naturalisation as a rehabilitation option are also described.

Introduction

The Oak Ridges Moraine (ORM) is the largest moraine in Southern Ontario. It is 160km long, stretching from the Niagara Escarpment in the west, to the Trent River in the east. The ORM is a kame moraine, mainly consisting of till, sand and gravel, with some clay and silt. This distinctive physiographic feature provides habitat for significant plant and animal species and is the headwater for numerous watercourses, including cold water fish habitat.

There are more than 190 aggregate pit sites on the ORM. The ORM was chosen as the physiographic unit for this study of pit naturalisation since there is such an intermingling of natural habitat and aggregate pits.

Pits having a range of active and passive rehabilitation histories occur. Pits which were active 50 or more years ago are also present.

The study objectives were to determine critical factors for naturalisation of aggregate pits and to develop a framework for a pit naturalisation model and the pit naturalisation planning process.

Study Methods

Twenty pits were randomly chosen for study. Five replicates were studied for each of the following categories:

(A) active rehabilitation 10 or more years ago;
(B) active rehabilitation less than ten years ago or (in one case) grading only occurred more than 10 years ago;
(C) no active rehabilitation, pit abandoned 15 or more years ago;
(D) no active rehabilitation, pit abandoned less than 15 years ago.

Study plot histories ranged from those which had been rehabilitated within 2 years, to those which had been abandoned for more than 50 years.

Physical and biological data were collected from six hundred quadrats. Vegetation, reptiles, amphibians, birds and mammals were inventoried. Site and rehabilitation history were determined during owner/operator interviews, review of government files and through air photo interpretation. Landscape context was assessed from topographic maps and air photos.

Computer analysis (CANOCO, DECORANA and TWINSPAN) was used to ordinate the physical and site history data along with plant species richness and density data to determine key factors contributing to establishment of vegetative communities.

A review of literature on site restoration, landscape ecology and conservation biology was completed to identify factors which facilitate successful site naturalisation.

The results of the field and literature research provided the basis for defining naturalisation as it relates to pit rehabilitation and for listing potential goals for pit naturalisation. Key steps in the pit naturalisation planning process were identified. Finally, an overall approach to constructing a model for pit naturalisation was prepared.

Results

Physical factors which affected the most widespread plant species were soil drainage and soil texture. These physical conditions are generally controlled by geology, soils and topography. Operational and rehabilitation history can modify these physical factors, for example, ditching or soil ripping will improve drainage and reconstructing a soil horizon will improve texture, as well as fertility and drainage.

The two principal plant communities that developed on the 20 pits were forb meadows and weedy annuals. Trees and shrubs communities were not dominant. Overall 54% of the dominant plant species were native.

Forb meadows and weedy annuals were prominent in both actively rehabilitated pits and abandoned pits. Weedy annuals were prevalent on steep, dry (often south-facing) slopes which were frequently also subject to erosion.

Many of the dominant grasses and herbs present in the forb meadows were alien species which are used in agriculture, pit rehabilitation and road right-of-way seeding . These species include: Red Fescue, Redtop, Smooth Brome, Quack Grass, Timothy, Alfalfa, Birdfoot Trefoil and Bird Vetch. These widespread alien plant species were prevalent in the forb meadows of both rehabilitated pits (which were up to 16 years old) and abandoned pits, many of which had been abandoned for 7 to 30 years.

If a native plant community is to dominate early in the rehabilitation process, different seed mixes than are presently used will have to be applied. Provision of physical structure such as terracing on slopes and mounds on the pit floors will also assist in promoting native species communities.

It appears that if a forb meadow is the rehabilitation objective, naturalisation will provide this vegetative community during the first 20 to 30 years following extraction. This developed on level areas of most pits regardless of rehabilitation history.

Without active planning and management, significant tree and shrub invasion will not occur for the first 20 or 30 years, on sites which have been seeded with grasses and legumes. More rapid invasion of trees and shrubs can be encouraged by maintaining or enhancing linkages with adjacent treed areas and ensuring that the soils are not compacted.

The presence of surface water consistently increased the variety of plants and animals present in pits. Breeding bird density was also higher in pits with water.

Differences in soil pH and organic matter between abandoned and rehabilitated sites decreased in time. As time passed organic matter increased in abandoned pits where topsoil had not been applied.

What Do We Mean by Pit Naturalisation?

Pit naturalisation is an active planning and managemnet process designed to meet documented, site specific ecological, social, and economic goals. Natural biological, chemical and physical processes are directed and augmented by a series of active and passive activities by the operators.

Naturalisation is not the do nothing, pit abandonment scenario which occurred at some sites in the past. Rather, naturalisation is working with and directing Nature toward a rehabilitation scheme which features target vegetation, fish and wildlife communities. Colonization by desirable wild plants and animals is encouraged and maximized. Ecological succession will play a key role in the naturalisation process.

Active intervention and management by the pit operators would involve such tasks as creation of physical structure as surface mounds and shallow depressions, soil preparation, initial plantings and nurse crops to improve soil, prevent erosion and establish colonies of plants which will provide shelter and a seed source for continued site colonization.

Figure 1 shows key planning steps in the pit naturalisation process. Details to include in the site specific naturalisation plan would include: soil preparation: shaping and tillage, selection of vegetation species to introduce, methods of sowing and/or planting, also planting and sowing patterns and density, creation of wildlife habitat features, follow-up plantings, and subsequent management and maintenance work.

Setting Goals for Pit Naturalisation

Ecological, social and economic goals to consider in a pit naturalisation plan are listed in Table 1.

FIGURE 1. KEY STEPS IN THE PIT NATURALISATION PROCESS.

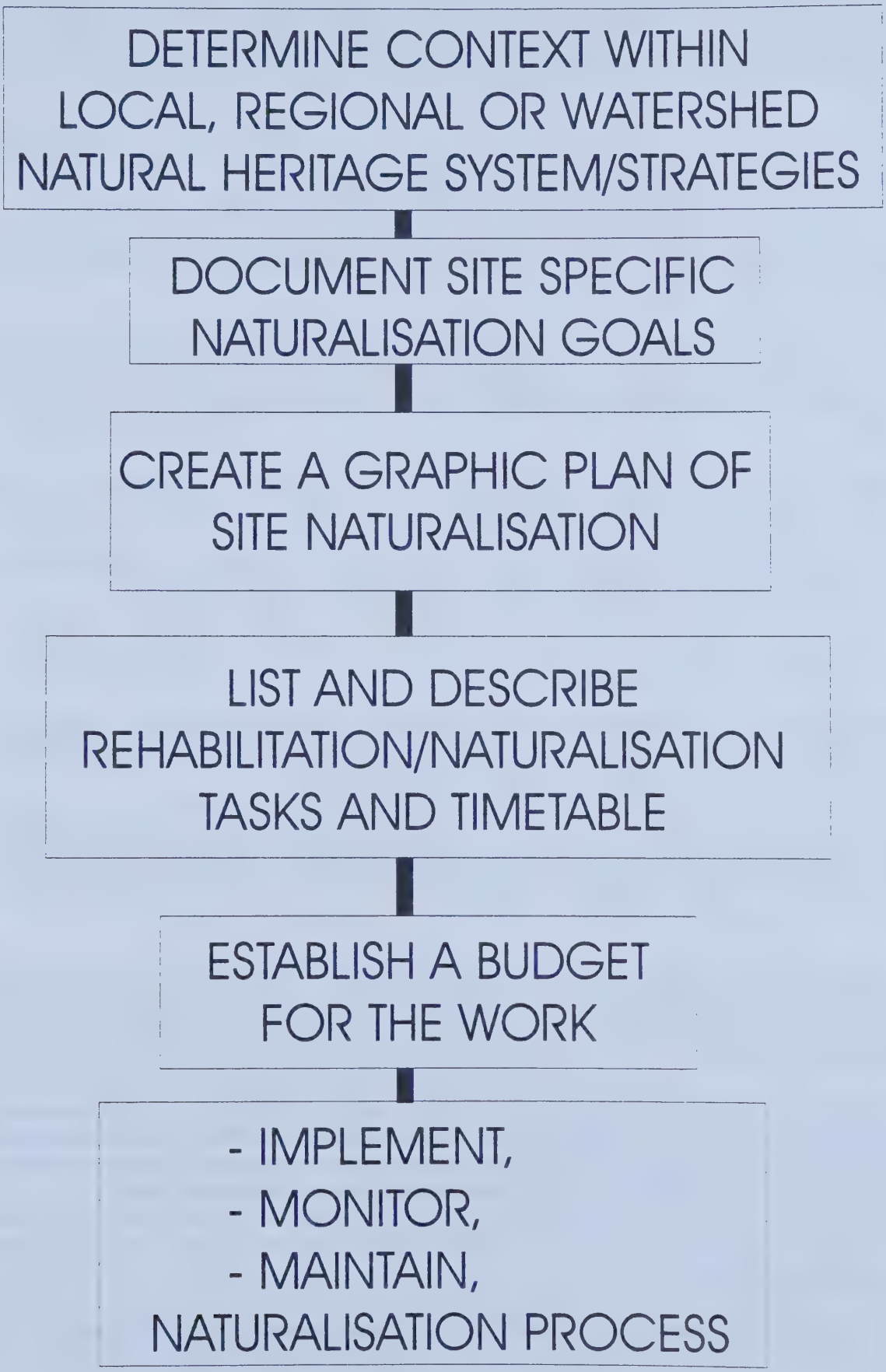


Table 1. **Goals for Pit Naturalisation**

(a)	ecological:	-	control erosion and sedimentation[1]
		-	maximize habitat diversity, if a large site
		-	add area to an uncommon habitat
		-	add diversity to the landscape range of habitats
		-	add area to an important off-site habitat
		-	improve linkages/corridors to off-site habitat
		-	maintain or expand habitat for rare species or other target species
		-	add surface water and/or wetland habitat
		-	maintain/improve soil fertility and structure
		-	have native species dominate the vegetation community
		-	achieve high Floristic Quality
		-	maximize plant and animal diversity if recreation or nature interpretation are objectives
		-	implement a system which is stable, self-sustaining and requires minimal maintenance
		-	minimize presence of weedy nuisance species.
(b)	social:	-	create a site which has social, recreational, educational benefits
		-	minimize pest species and conflicts with neighbours regarding weeds etc.
		-	create a site which has public relations benefits in the local community
(c)	economic	-	maximize cost-benefit of rehabilitation effort for the operator.
		-	minimize long-term maintenance costs
		-	maximize flexibility for future high value land uses on the site
		-	minimize off-site economic costs, eg. pest damage by species originating in the naturalised pit.

[1] Erosion control must prevent off-site impacts. Beyond that, however, other ecological goals may benefit from erosion and sedimentation as a natural form of grading, as opposed to traditional grading and seeding for complete control at the cost of habitat impoverishment.

Approach to a Model for Naturalising Pits

Figure 2 shows ten key factors which should be considered when preparing a model for naturalising pits. There may be additional factors which warrant attention.

Figure 2 illustrates that goal setting is central to the pit naturalisation process. The outer ring which connects the factors indicates the interaction between all of these factors.

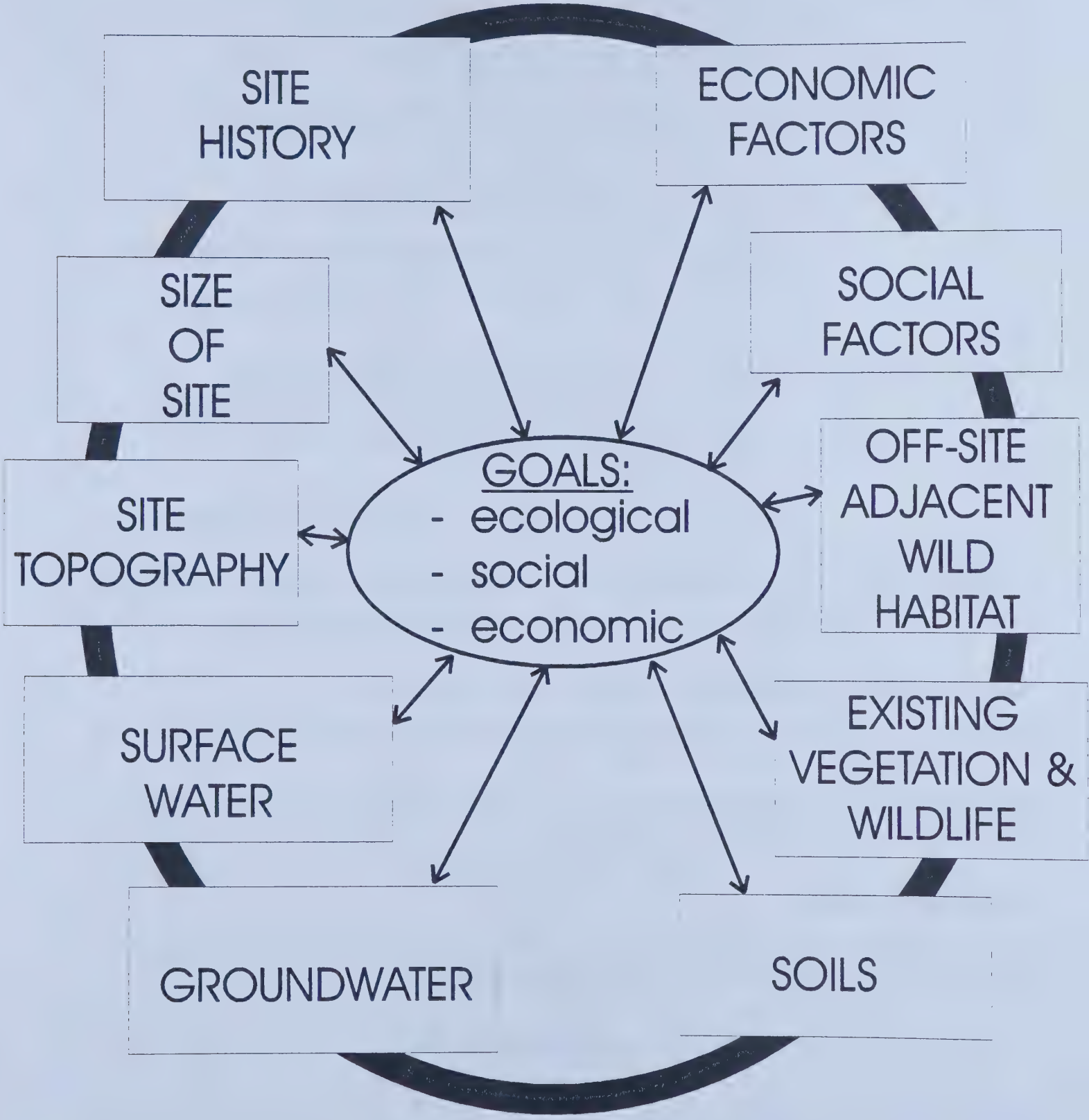
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FIGURE 2. APPROACH TO PREDICTIVE MODEL FOR NATURALISING PITS.



Brant Prairie: Union Gas Customer Service Centre, Brantford Ontario

Michael J. Hensel, Landscape Architect, C.S.L.A., O.A.L.A.
Jeffrey Thompson, Environmental Biologist

The Walter Fedy Partnership
Architects, Engineers, Project Managers & Landscape Architects

ABSTRACT

The Walter Fedy Partnership, a multi-disciplinary design firm established in 1951, serves North American and international customers from their main office in Kitchener Ontario, as well as an engineering office in Lakeland, Florida. The firm's integrated services include landscape architecture, natural ecology, architecture, mechanical, electrical, structural, civil and investigative engineering, as well as estimating, construction and project management. The Walter Fedy Partnership serves customers in both public and private sectors.

The Walter Fedy Partnership's work at the newly constructed (1995) Union Gas Customer Service Centre in Brantford included architecture and engineering, as well as landscape architecture and ecology services through Michael Hensel and Jeffrey Thompson. The overall project (building and site) embodied environment-first principles to achieve a totally integrated site development.

Brant Prairie is a four-acre ecological restoration of a tall grass prairie, wetland and Savannah communities within Brantford's urban environment, and was instigated through Union Gas' land stewardship and environmental action initiatives. These initiatives led to restoring part of Brantford's historic landscape in order to recreate sustainable ecosystems that emulate historic ecosystems through life forms, vertical stratification and dominant plants. Through ongoing protection and management of the prairie, the initiatives also aimed to encourage the diversity and dynamics of these ecosystems, while creating a community resource for visitors to learn about natural heritage. Investigating neighbouring natural areas inspired this restoration, resulting in ecological, educational and economic benefits to the surrounding community. The Brant Prairie is becoming a nationally recognized site, helping to enhance Union Gas' corporate identity. Accomplishments of the environmental initiatives include protecting the sedge wetland containing fringed gentian (Gentiana crinita), a regionally rare species; maintaining the dynamic water budget while protecting the sedge wetland from roadway contaminants; creating a tall grass prairie similar in diversity and aesthetics to Brantford's surviving prairie remnants; creating a wildlife habitat for butterflies, birds and aquatic species, and rediscovering partridge pea (Cassia fisciculata) by uncovering a historic seed bank.

Now in its third growing season, Brant Prairie is gaining public acceptance and national recognition. As Union Gas continues to monitor the project they are becoming more confident that this example of corporate land stewardship can be a model for everyone to consider when developing or re-developing their own property.

LESSONS LEARNED FOR ECOLOGICAL REHABILITATION FROM AN INVESTIGATION OF THE REGIONAL MUNICIPALITY OF WATERLOO, ONTARIO

Soonya Quon
School of Urban and Regional Planning
University of Waterloo

ABSTRACT

Ecological rehabilitation has a potential role in improving the ecological integrity of large areas through reconnecting and reintegrating landscapes fragmented by human use. The research aimed to find what factors, if any, pose obstacles to or opportunities for ecological rehabilitation activity, and consequently might hinder its contribution to environmental sustainability.

The Regional Municipality of Waterloo, having a goal of becoming a sustainable regional community, was investigated as a case study of potential obstacles and opportunities to rehabilitation practice. Local practitioners' experiences were compared with literature findings. This comparison highlighted that the literature and practitioners may focus on different scales for rehabilitation, and emphasize different aspects of the process. While the literature stressed a need to consider project context and proposed somewhat general guides to practice, practitioners emphasized a need for attention to project implementation, and voiced pragmatic and site-specific concerns, such as funding, access to sites, and the difficulties posed by a public preference for manicured landscapes.

The findings led to recommendations to aid planners and practitioners to facilitate, and the policy context to be altered, to facilitate future ecological rehabilitation in the Region of Waterloo.

Introduction

Ecological rehabilitation has taken root in the Regional Municipality of Waterloo. While the Region of Waterloo may be similar to other southwestern Ontario mixed rural/urban municipalities, there is a history of strong support for improvement of the natural environment in regional planning policy. The Region of Waterloo declares an aim to become a sustainable regional community, including environmental integrity (***Regional Official Policies Plan*** 1996: s. 2.1), and explicitly supports ecological rehabilitation (described under various terms) of degraded areas. The many projects found in the Region of Waterloo, differing in size, involving different players, and arising from varied motivations, make this an interesting and appropriate place to examine opportunities and obstacles encountered in the practice of ecological rehabilitation.

This investigation of cases found in the Region of Waterloo sheds some light on how the practitioner, the planner and the politician (through the development of the policy context) might facilitate undertaking ecological rehabilitation. Therefore, this presentation concentrates on lessons learned and recommendations offered by rehabilitation practitioners.

The presentation will clarify use of the term "ecological rehabilitation," and provide a brief overview of the research process and the findings forming the basis of recommendations and assertions, and, finally, present a summary of the key lessons and recommendations arising from the research.

Overview of the Research

The research was undertaken as part of the author's Master of Environmental Studies degree in Planning, at the University of Waterloo. The author entered the research with an interest in ecological rehabilitation as a means to reconnect disrupted ecological patterns in inhabited landscapes. Rehabilitation was viewed as a means to relink remnant patches of native ecosystems; broadly, to increase a landscape's "ecological function." The research originated with a belief that taking a landscape or regional approach to the identification and coordination of rehabilitation efforts would present the wisest use of often scarce rehabilitation resources. However, the research uncovered more pragmatic challenges facing practitioners, challenges that hinder landscape or regional approaches to planning and management of rehabilitation activities.

The term "ecological rehabilitation" was adopted to describe those activities seeking to intentionally improve an area to an ecologically self-sustaining state. The term was favoured over the more common "ecological restoration," because it does not exclude those projects not seeking to "restore" a site to an historic state. "Rehabilitation" seemed to better acknowledge the role of human values in shaping a project, and to encompass a wide range of projects with different degrees of intention/intervention. The author acknowledges continued debate about appropriate terminology for this activity (e.g., Cairns 1993).

Interviews with practitioners from eleven urban and rural rehabilitation projects in the Region of Waterloo formed the basis of the findings. These cases were selected from among some 57 projects in-progress or completed in the Region of Waterloo, from an inventory of 79 projects (not including urban, private lots) in various stages of completion. The experiences uncovered might be considered snapshots of the selected projects, rather than a comprehensive documentation of the state of rehabilitation practice in the Region of Waterloo. Even so, several key issues and concerns surfaced that likely reflect the experiences of other projects.

There is a great deal of prescriptive literature on ecological rehabilitation; many authors offered advice especially on the process or steps to take in organizing and implementing a rehabilitation project. The experiences of the practitioners were contrasted and compared with literature findings, highlighting concurrence of opinion, and apparent gaps in the literature where future research efforts might be concentrated.

Findings

While not all of the research can be presented, several of the key findings are discussed below:

Project selection and scope

Contrary to much of the prescriptive rehabilitation literature, which urges the use of landscape scale inventories and assessments as a basis for identifying, selecting (e.g., Hobbs et al. 1993, Riley and Mohr 1994, Forman 1995) and prioritizing rehabilitation sites (e.g., Schreckenberg et al. 1990, Dyer 1992), projects in the Region were selected without much consideration of their context, or of the location of other rehabilitation projects.

Of those projects examined, project location was determined much more by factors such as how amenable a landowner (e.g., in the case of agricultural sites) or local governance agency was to the project, the visibility of the site, or other associated activities and land uses (e.g., projects initiated by students and school staff were most often confined to school property). Opportunities for ecological rehabilitation are rare and need to be seized when they present themselves. Practitioners either did not seem to consider useful an examination of a project's broader context, or did not have the resources to include this broader scope in the project. In any case, few projects examined included the subwatershed or broader landscape as part of a project.

Planning, goals and objectives, monitoring

In the literature, goal setting and planning were viewed as key stages in the rehabilitation process (e.g., Caldwell 1991, Hobbs and Norton 1993, Daigle and Havinga 1996). Clear goals were viewed as helpful in minimizing cross-boundary or jurisdictional conflict (Bowles and Whelan 1994). Goals should be flexible to allow for the dynamic change of ecosystems; different objectives need to be set to assess change in ecosystem structure, separate from function, or from the social function of the site (Westman 1991, Fitzgibbon 1992). For rehabilitation success to be gauged, project objectives must be measurable and scheduled (Westman 1991, Cairns 1993). Some authors discussed and proposed particular rehabilitation evaluation criteria (e.g., Berger 1991, Kondolf and Micheli 1995); in general, it was agreed that evaluation must be an ongoing process, as rehabilitation has no clear end point.

Planning, goal setting, and the development of specific objectives were inconsistent in the rehabilitation projects examined. Rehabilitation techniques tended to depend on available resources, and decisions were made in reaction to circumstances as they arose. Monitoring, or methodical tracking of changes to a site for the purposes of learning or modifying management, was rare, although generally viewed as a good idea by practitioners. Despite this, when questioned about project success, practitioners often felt confident in declaring a project a success based on qualitative and short term observations.

Challenges or hindrances

Rarely did the rehabilitation literature acknowledge or offer advice about the daily and common challenges described by practitioners. For example, practitioners cited a common challenge to projects as being the difficulty overcoming prejudices and preconceived ideas about what a "natural" space should look like; rehabilitated sites often lack the aesthetic appeal of landscaped sites. The widespread political and community support, resources and labour, that practitioners considered necessary for project realization were not as well acknowledged in the prescriptive literature. Practitioners also asserted the need for long term support (especially funding) and continued commitment to a project, without which a project can fail. The rehabilitation project can be used as a vehicle to instruct the community on the benefits of the specific project and on ecological rehabilitation in general. However, practitioners often failed to thoroughly investigate others' rehabilitation experiences in their own region prior to undertaking a project and tended to consider their own project as unique. The difficulties presented by a lack of knowledgeable and effective leadership and volunteers were also noted by practitioners.

Lessons Learned

What lessons might be synopsized for practitioners, for planners and for development of the policy context from the research and the comparison of the experiences of the practitioners with the literature findings?

First, opportunities for ecological rehabilitation, and recognition of the role of rehabilitation in achieving ecological sustainability, need to be increased in the policy context. The policy context of the Region of Waterloo was found to be generally supportive of ecological rehabilitation. However, policy context support might benefit from more explicit recognition of ecological rehabilitation through use of more consistent terminology, and the creation of more requirements for it to occur. Provincial land use policy naming and identifying opportunities for ecological rehabilitation should be reinstated. Incentives for land owners to become involved in ecological rehabilitation on their properties should be increased.

Second, those in a position to encourage and facilitate communication about ecological rehabilitation should do so. Municipal planners are situated to bring community attention to degraded areas and to gel public opinion about the need for rehabilitation, and can help shape municipal land use policy. Planners have a strong role to play in encouraging ecological rehabilitation in association with new development. Planners and other municipal and regional staff are in a position to know of many disparate rehabilitation projects within their jurisdiction, and can help facilitate communication among practitioners.

Third, both the literature and the practitioners offer ideas about what needs to be included in a successful rehabilitation project. Qualities such as interconnection among projects, and consideration of the project's social, political and ecological context will highlight how individual projects contribute to a landscape vision. Setting goals and objectives, but being flexible in incorporating new information as it arises from project monitoring, is appropriate for ecological rehabilitation projects, that are still largely experimental. Above all, communication, both learning from others' experiences and sharing what has been learned with others, both to garner support for a project and to contribute to the growing knowledge about ecological rehabilitation in different ecoregions, needs to be encouraged. Practitioners are in a position to shape individual projects, seek out partners and colleagues in the community, and to record and share information about specific projects.

Conclusions

Understanding is growing about how the ecological integrity of the southwestern Ontario landscape might be improved in spite of threats from increased urbanization of rural lands, homogenization of agricultural tracts, and complex environmental change. Ecological rehabilitation is gaining profile as a means to reconnect and reestablish this landscape. Investigating, describing, and continually examining ecological rehabilitation projects needs to continue, and communication and coordination among projects needs to increase, to overcome both the long-term, and daily challenges to projects, and further our understanding of ecological rehabilitation practice.

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Reconfiguration of Westside Creek and Marsh, Bowmanville.

Shawn R. Taylor M.Sc., R.P.Bio.
Senior Biologist, Dillon Consulting Ltd.
100 Sheppard Ave E., Toronto, Ontario

Construction of the 27.4 ha reconfiguration of Westside Creek and Marsh is planned to begin during winter 2000, requiring 3 years for completion to allow limestone quarrying under the existing provincially significant wetland. The subject of a four year study of biology and hydrology, the Waterfront Regeneration Trust-brokered proposal details the largest, most detailed fish habitat compensation plan yet completed in Canada under the *Fisheries Act*. The Westside Creek valley will be rerouted a distance of 2.8 km with over 4 km of lowflow channel threaded through an existing Ontario Hydro towerline corridor. Valley banks will be stabilized with extensive bioengineering, shoreline plants and innovative steep slope plantings using straw and wood wattles to establish terracing. Along the upper banks, a portion of the waterfront trail will be blended in and planted with a mixture of hardwood seedlings and heritage fruit trees. Large woody debris will be added to the stream to add overhead cover habitat, increase the complexity / diversity of habitat niches and increase channel roughness to provide resources for resident fish, invertebrates and amphibians.

In Westside Marsh, two new deep basins each of 2.5 and 1.6 ha will be constructed as largemouth bass and northern pike spawning, rearing & nursery habitats. These will have integrated frog ponds, underwater cover, extensive aquatic plantings and riparian shorelines stabilized with a custom seed mix of plant species found in the marsh. Carp will be strictly controlled from entering these basins for about three years until vegetation is well stabilized and a large bass population is established. Four islands and five deep basins will be retrofitted into the existing shallow open water basin of the marsh. These will increase edge habitat and deep water refuge for fish, while diversifying habitats for amphibians, nesting birds and reptiles along the intricate shorelines of the islands. An existing topsoil berm will be reshaped along the waterline and as a bluff rising from the marsh. New habitats will be seeded with custom blends of aquatic species or prairie grasses and wildflowers native to the site and supplemented with oak tree seedlings - the intent is to develop an oak forest savanna over the long term.

Rehabilitation of Dufferin Aggregates' Milton Quarry

Authors: Ken Zimmerman, MLA, Landscape Architect Intern, Dufferin Aggregates
Sarah B. Lowe, MSc., Property and Resources Manager, Dufferin Aggregates
Sergio Carbone, BSc.h., Property and Resources Coordinator, Dufferin Aggregates

Abstract

Progressive rehabilitation is a vital link between aggregate extraction and the development of a future conservation land use. Rehabilitation at Dufferin Aggregate's Milton Quarry, in the Region of Halton, provides an excellent opportunity to develop a working example of responsible stewardship of our natural resources.

This paper reviews rehabilitation objectives, practices and results at the Milton Quarry to evaluate current techniques and enhance future rehabilitation. Rehabilitation to date includes the preparation of cliff faces, shorelines, and islands and the establishment of vegetation for a future lake/wetland habitat. A demonstration area which will be allowed to fill with water will provide a valuable example of the long term land use and promote opportunities for research, monitoring and education.

Introduction

Dufferin Aggregates, a division of St. Lawrence Cement Inc., has operated a dolostone quarry on the Niagara Escarpment in the Region of Halton, in Southern Ontario, since 1962 (Figure 1). The quarry supplies 4-8 million tonnes per annum of high quality aggregates to the Greater Toronto Area. Progressive rehabilitation provides a vital link between the extraction of aggregate and the development of a valuable conservation land use. The proposed rehabilitation plan for the 467 ha quarry includes approximately 271 ha of lakes, over 13 km of cliff face and 14 km of shorelines.

Geology

The Escarpment brow and the adjacent land to the north which includes the quarry, consists of the Dolostone of the Middle Silurian Amabel formation (408-438 million years old). 10 to 30 m of dolostone overlay the shaley dolostone of the Middle Silurian Reynales formation. The escarpment feature runs through Southern Ontario from Niagara Falls to Tobermory.

Natural Heritage

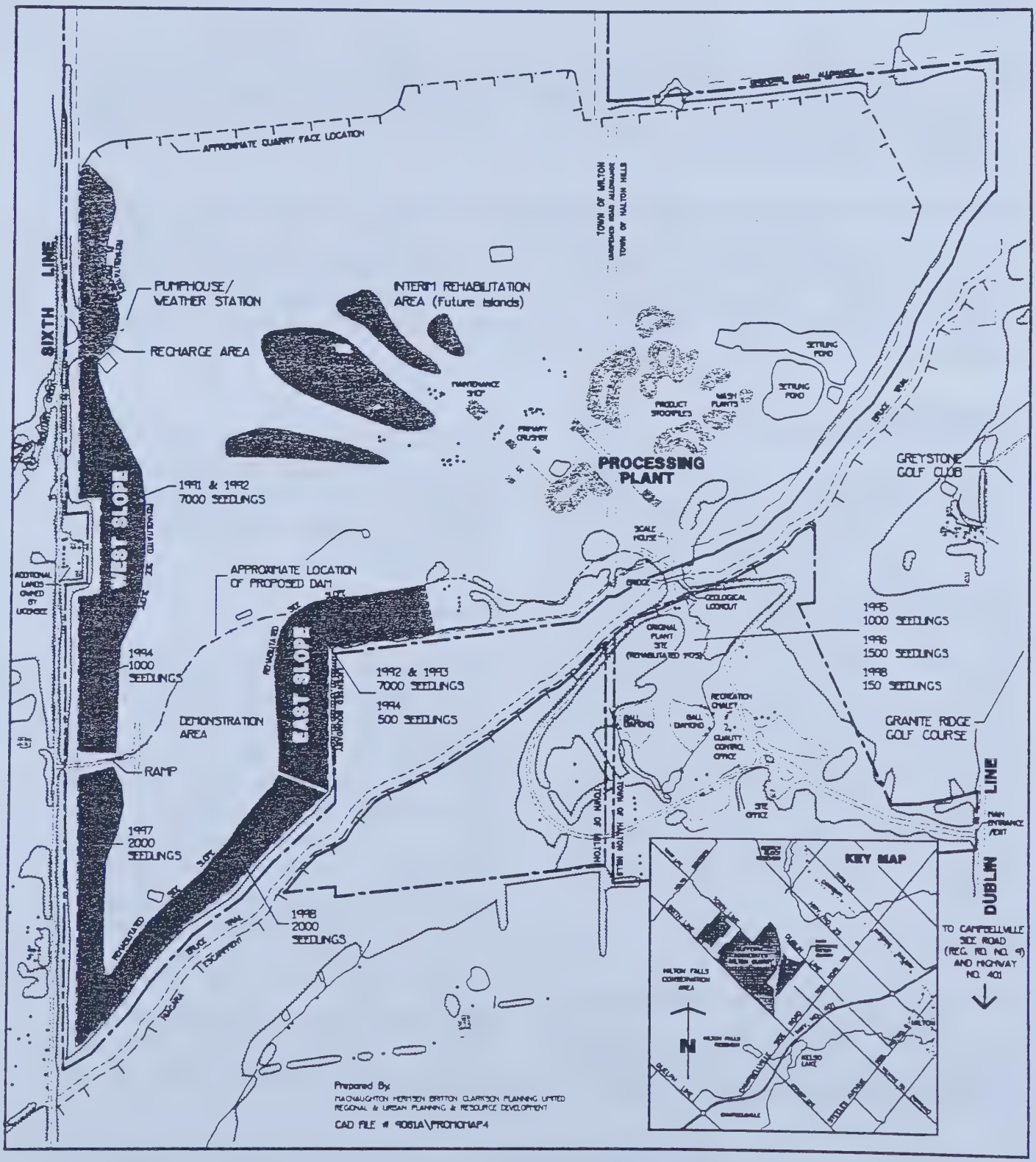
The Niagara Escarpment has been designated a world biosphere reserve (Francis, 1990). The quarry itself is situated in an area of rich natural heritage. The site is next to the Hilton Falls Complex, the largest designated Environmentally Sensitive Area (ESA) in the Region. The Complex is largely a mixed forest tract. The diversity of the forest communities are a reflection of the transition between the Eastern Deciduous and the St. Lawrence-Great lakes Forest Regions. The Complex consists of over 700 ha of mature sugar maple stands, numerous marshes, deciduous swamps, conifer plantations, tributaries of Sixteen Mile Creek, and cliff

Contact: Ken Zimmerman, MLA Dufferin Aggregates, 3300 Hwy 7, Suite 400, Concord, Ontario, L4K 4M3, (905) 761-7500

Milton Quarry

Dufferin Aggregates

a Division of St. Lawrence Cement Inc.



face and talus slope communities (Braid, 1998).

Cultural Heritage

The quarry is close to numerous public parks, owned by the Halton Region Conservation Authority. These include: Hilton Falls Conservation Area which borders the western boundary of the site, Kelso Lake, Rattlesnake Point, Burns, and Crawford Lake Conservation Areas. The Bruce Trail travels along the southern boundary of the quarry, over the Dufferin foot bridge and through lands owned by Dufferin. Merged into the cultural and natural landscape of the Escarpment are numerous old lime kilns and quarries which were built in the 1870's and operated until the 1920's.

Education and Partnerships

Dufferin Aggregates considers itself a part of each community in which it operates and promotes an open communication approach. The Milton Quarry is already well visited for educational purposes. Approximately 40 guided tours a year include classes from elementary, secondary and university levels and public groups such as the Royal Ontario Museum.

Rehabilitation offers exciting opportunities for partnerships to benefit present practices and the future final use. Dufferin Aggregates has a long standing partnership with Scouts Canada. The Scouts are important to our tree planting program. The Company also works with the Bruce Trail Association, the Halton Region Conservation Authority and the local community to enhance nature trail access through the establishment of new hiking trails on Dufferin property and nearby lands.

Final Use

Through collaboration with the Halton Region Conservation Authority and the Ministry of Natural Resources, the Milton Quarry will be developed into an extensive naturalized area of lakes and islands, to enhance water availability within the Sixteen Mile Creek watershed. The proposed final use provides the private sector with the opportunity to develop an unique asset with the potential sharing of a valuable natural area for possible public access, conservation, education and recreation uses.

Rehabilitation Objectives

The rehabilitation process aims to create a final use that is ecologically productive and of value to future generations. The three major components of rehabilitation include designing new landforms, replacing soils and establishing vegetation and wildlife habitat.

The objective of rehabilitation practices at the quarry is to provide conditions that encourage diversity, natural succession and the development of wildlife habitat. Although originally a terrestrial environment of agricultural fields and mixed forest lands, the site will become an aquatic resource with islands, wetlands, cliffs, and shorelines.

Progressive Rehabilitation

The first stage of rehabilitation occurred when the plant was moved in the mid 1970's. For the past 13 years rehabilitation has occurred progressively (i.e. hand in hand with operations). The sequence includes:

1. stripping the topsoil, subsoil and overburden to expose the high quality dolostone

2. separation of the topsoil from the subsoil and overburden when possible
3. hauling and placement of pond fines from the processing plant
4. hauling and placement of the overburden, rubble and rock
5. grading to create the desired landforms.
6. vegetation establishment
7. natural succession of the slopes is accelerated by seed rain from the surrounding lands.

Soil Conditions

The predominant soil series is the moderately well drained Farmington Loam with pockets of poorly drained organic soil. The overburden is typically glacial till with abundant boulders and rubble of various sizes. Depths across the site range from little or no soil at the outcrops to isolated areas that can be up to 3 m deep. In the past, the shallow soils have had marginal value for grazing or other agricultural purposes.

The pH of the undisturbed Farmington Loam soils on the site is generally in the 7.5 to 8.0 range. Although limited in quantity, the organic soils in former lowland areas on site exhibit a pH of around 6.5. Phosphorus and Potassium levels are generally low with high levels of Magnesium.

The replaced soils are characteristically fine with an altered soil structure as a result of the stripping and placement to create the desired landforms.

Pond fines, a by-product of processing from the wash plants, are used as a base for slope creation and to enhance future water retention within the quarry. Average particle size distribution of the silt loam textured material is approximately 27 % sand, 60 % silt and 13 % clay (Fraser, 1996).

The "Gap"

The plant was moved in the mid 1970's from the area at the foot of the escarpment below the "gap" to obscure the view of the operation. The site was rehabilitated to provide park facilities which Dufferin employees and public groups use for recreation and meetings. The disturbed slope was graded, covered with topsoil, seeded with grass and planted with 1,500 sumac seedlings. In the spring of 1995, 1996 and 1998, over 2,000 additional seedlings of native species were planted to accelerate the screening of the gap and to help restore the natural character of the slope.

Desired Landforms

Cliff faces resulting from extraction range from 10 m to over 30 m in height depending on the topography of the land and the depth of the Amabel formation. The exposed cliff faces and slope heights resulting from the backfilling process are quite variable throughout the rehabilitated areas.

Initially (1985-89), rehabilitation of the future lake edges within the quarry involved backfilling the entire quarry face from top to bottom at a 2:1 or 3:1 slope, seeding with a grass mix and planting seedlings. Since 1991, some of the quarry walls have been retained as cliffs. Many of the backfilled slopes are now limited to the bottom 1/3 to 1/2 of the faces to provide an edge for the future lakes.

A minimum elevation of 310 m.a.s.l. is required to ensure a land base above the predicted final water elevation of 307.8 m.a.s.l. This has resulted in cliff faces above the slopes that range from 2m in height along the most southern slope to almost 10m along the western boundary of the property. The

slopes created to date vary in grade and aspect. Slopes range from 2:1 to almost 10:1 in the most southern corner of the quarry and face southeast, northwest, north and south.

No mechanical compaction of the soils is practiced other than the compaction resulting from the placement and grading of material by the 60 Tonne trucks and D8 dozers. The slopes are ripped with a single shanked ripper and a D8 dozer prior to tree planting.

Demonstration Area

Previous rehabilitation practices focused on the edges and islands of the future lake. The next step includes the design and construction of a demonstration area that will be allowed to fill with water. The location of this area is illustrated in Figure 1.

A detailed design/plan (Figure 2) has been developed to guide the construction of this 20 ha demonstration area. The plan includes the construction of a berm up to 5 m in height to allow for an interim water level of up to 4 m in depth. This plan is currently on display in our employee chalet at the quarry.

The design incorporates sinuous edges, islands, an irregular topography on the quarry floor and a diversity of graded and ungraded slopes to provide variability in water depths and improve landscape diversity.

The top 2/3 of the slopes in the area have been covered with topsoil and planted with trees. The topdressing layer is a combination of topsoil, rubble and stumps placed to enhance landscape diversity and promote the development of micro-habitats.

The creation of shallows along the edges and throughout the pond area will enhance wetland development. These areas will have a limited water depth of no more than 2 m to create littoral zones and fish habitat.

Pond fines placed on the quarry floor and against the walls from 1990 to 1995 enhance water retention and provide variable substrates within the flooded area. Placement of rock and brush piles will increase the variability in the substrate and enhance aquatic and shoreline habitat. The demonstration area will incorporate the existing exposed cliff faces and four mounds of fines/overburden that have been graded to form islands and mud flats. These features will enhance aesthetic and wildlife habitat value and provide refuge.

Predicted water levels on the slopes for both the interim and final levels have been identified to develop planting designs and ensure the planting of suitable species for shoreline and terrestrial habitats. The filling of the demonstration area will start after construction of the berm in late 1998/early 1999.

Vegetation Establishment

Rehabilitated areas have only been seeded where erosion was considered a problem. Tree and shrub nursery stock planting is an important component of the quarry rehabilitation. Most recent efforts have focused on planting a diversity of native species. Scouts Canada has maintained a very significant role in the planting of over 21,000 seedlings in the quarry over the last 8 years. Species planted throughout the rehabilitated areas are listed in table 1.

A transplanting program was initiated in 1996 to 1998. Over 250 individual seedlings and young saplings as well as 72 plugs of forest floor soils were transplanted from

Design Features

Lake Construction

Lake Design

Cliffs

Terrestrial Slope

Habitat Enhancement Techniques



Planning for the Future

The Rehabilitation of the Milton Quarry: Phase1

Table 1: Nursery Stock Species Planted in the Quarry

Species	No.	Year Planted
White Cedar	3,900	1991,93,95-98
White Pine	3,950	1991-95,97
White Spruce	4,750	1991-94
Tamarack	1,500	1992
Red osier Dogwood	1,300	1991,97-98
Highbush Cranberry	800	1991,98
Black Locust	650	1994, 97-98
Silver Maple	600	1994, 97-98
Autumn Olive	500	1991
Common Lilac	500	1991
Russian Olive	500	1991
Nannyberry	400	1997-98
White/Green Ash	400	1991,96-98
Choke Cherry	200	1997
Red Oak	200	1997-98
Red Pine	200	1995
Slender Willow	200	1998
white elm	200	1997-98
alternate leaved dogwood	150	1995,98
Bitternut Hickory	100	1998
Carolina Poplar	100	1998
Grey Dogwood	100	1998
Norway Spruce	100	1996
Pussy Willow	100	1998
Sandbar Willow	100	1998
European Larch	50	1991
	21,550	

areas to be extracted on site (Table 2). Specimens and areas are identified and flagged in the field during the summer/spring months. In the fall, the plants are either transplanted individually by hand or in "plugs" (groups) using a 30 inch tree spade. The plants or plugs are wrapped in burlap, transported to the rehabilitated slopes and planted in both shaded areas under the thriving sumac and more exposed areas on the more recently created slopes.

Monitoring

The Company has started to monitor the success of the rehabilitation program. Plant growth and natural regeneration has been monitored over the past 5 years (Monet, 1994; Monet, 1996a; Monet, 1996b; Monet, 1997; Monet, 1998) along with survival and growth of transplants (Morris, 1997). The annual qualitative plant inventories are used to document and assess the change in vegetation cover over time and to help determine future revegetation strategies.

Table 2: Saplings Transplanted on Site

Species		No.	Yr Planted
Alternate-leaved Dogwood	PI	6	1997
Balsam Poplar	I	12	1997
Basswood	I	1	1997
Bitternut Hickory	PI	32	1997,1998
Black Cherry	PI	8	1997,1998
Black Raspberry	P	1	1997
Bush-honeysuckle	P	1	1997
Butternut	P	1	1997
Choke Cherry	P	13	1997
Common Blackberry	P	5	1997
Eastern Hemlock	I	1	1997
Flowering Raspberry	P	6	1997
Green Ash	I	1	1997
Heart-leaved Willow	I	1	1997
Mountain Maple	I	4	1997
Pin Cherry	I	16	1997,1998
Red Oak	PI	12	1997
Red osier Dogwood	I	16	1997
Riverbank Grape	P	3	1997
Round leaved Dogwood	I	2	1997
Running Strawberry-bush	P	1	1997
Staghorn Sumac	I	4	1997
Sugar Maple	PI	52	1997,1998
Swamp Black Currant	P	1	1997
Trembling Aspen	PI	3	1997
Virgin's Bower	I	1	1997
White Birch	I	7	1997
Wild Red Raspberry	P	25	1997
White Ash	PI	59	1997,1998
White Cedar	I	28	1997
White Elm	PI	26	1997
White Spruce	I	2	1997,1998
White Spruce	I	1	1997
		352	

Modified from Monet (1998)

P = planted in plugs
I = planted as individuals

The vegetation inventories are divided into two parts: an inventory of the rehabilitated slopes as a whole and an inventory of 14 transects set up from top to bottom along the slopes. The relative abundance, survival rates and height of species observed are described.

Ornithological Study

A bird study utilizing the British Trust of Ornithological Common Bird Census technique was initiated in the spring of 1998 to: determine the species currently inhabiting the rehabilitated areas of the quarry, establish any trends in numbers of these species over time and to document new species that colonize the site in the future (Sheppard, 1998).

The census involves a weekly walk along a pre-determined route throughout the breeding season to map the location and activity of every bird observed. At the end of the season, the data is transferred on a by-species basis and an assessment is made regarding the number of breeding pairs of each species. This quantitative approach will attempt to identify significant trends over time as the rehabilitated areas evolve.

Rehabilitation Results

Vegetation Establishment

Observations from the vegetation inventories and monitoring include:

- the survival rate of planted nursery stock is generally good with over 50 % survival. White Spruce, Tamarack, Silver Maple and Black Locust have had very good survival rates of 79 to 90 %. White Cedar and White Pine have had variable results ranging from 47 to 64 %.
- survival of nursery stock planted in 1997, following 2 growing seasons has been very good with a survival rate of over 80 %.
- Following one growing season, survival rates of woody species within the "plug" plantings are over 95 %.
- many herbaceous forest species are transplanted along with the woody species within the plugs.
- the surviving planted stock is generally growing well, especially White Spruce, Tamarack, Black Locust, and Red osier Dogwood. White Cedar, Red osier Dogwood and White Spruce have an average height of 1 to 1.5m. Tamarack can vary from 1.5 m to 3m in height while Black Locust are consistently 2.5 to 3 m tall.
- Growth rates appear to be better on the west slopes. Of the individuals examined, planted species can be 0.5 to 1m shorter on the east slope compared to the west. Stunted growth in some of the species, especially white pine has been observed on the northern section of the east slope.
- a high rate of recruitment by native trees, shrubs, with forest wildflowers in some areas.
- the rate of native herbaceous and woody volunteers is generally higher on the west slopes of the rehabilitated area than on the east slopes or the "gap". Approximate average densities of woody vegetation vary from a high of $0.75/m^2$ on the 1991-1992 west slopes to $0.60/m^2$ on the 1994 west slopes to a low of $0.1/m^2$ on sections of the east slope. Only one section of the east slopes has densities comparable to the 1991-1992 and 1994 slopes to the west.
- non planted woody species frequently observed on the slopes include: staghorn sumac, pin cherry, trembling aspen, white

Table 3: Colonizing Species Observed on the Rehabilitated Slopes

	Common Name	Scientific Name		Common Name	Scientific Name
	Trees, shrubs and woody vines				
Z	Manitoba Maple	Acer negundo		Tower-mustard	Arabis glabra
P	Red Maple	Acer rubrum		Jack-in-the-pulpit	Arisaema triphyllum
P	Silver Maple	Acer saccharinum		Swamp Milkweed	Asclepias incarnata
	Sugar Maple	Acer saccharum		Common Milkweed	Asclepias syriaca
T	Mountain Maple	Acer spicatum		Heart-leaved Aster	Aster cordifolius
	White Birch	Betula papyrifera		Heath Aster	Aster ericoides
	Bitternut Hickory	Carya cordiformis		Tall White Aster	Aster lanceolatus
	Virgin's Bower	Clematis virginiana		New England Aster	Aster nova-angliae
	Alternate-leaved Dogwood	Cornus alternifolia		Purple-stemmed Aster	Aster puniceus
	Gray Dogwood	Cornus cf. racemosa		Arrow-leaved Aster	Aster urophyllus
	Round-leaved Dogwood	Cornus rugosum	*	Yellow Rocket	Barbarea vulgaris
PC	Red-osier Dogwood	Cornus stolonifera		Nodding Beggarticks	Bidens cernua
	Hawthorn	Crataegus sp.		Devil's Beggarticks	Bidens frondosa
	Bush-honeysuckle	Diervilla lonicera		Beggarticks	Bidens sp.
*P	Russian Olive	Elaeagnus angustifolia	*	Field Mustard	Brassica rapa
*P	Autumn Olive	Elaeagnus commutata	*	Smooth Brome	Bromus inermis
	White Ash	Fraxinus americana		Shepherd's Purse	Capsella bursa-pastoris
	Ash	Fraxinus sp.	*	Nodding Thistle	Carduus nutans
*P	Black Walnut	Juglans nigra		Sedge	Carex cf. albursina
*	Juniper	Juniperus sp		Sedge	Carex deweyana
P	Tamarack	Larix laricina		Sedge	Carex hitchcockiana
*	Morrow's Honeysuckle	Lonicera morrowi		Sedge	Carex peckii
*	Tartarian Honeysuckle	Lonicera tatarica		Sedge	Carex cf. pennsylvanica
	Virginia Creeper	Parthenocissus quinquefolia		Sedge	Carex retrorsa
P	White Spruce	Picea glauca		Sedge	Carex sp.
P	White Pine	Pinus strobus		Sedge	Carex sparganioides
*	White Poplar	Populus alba		Sedge	Carex stipata
	Balsam Poplar	Populus balsamifera		Sedge	Carex tenera
	Large-toothed Aspen	Populus grandidentata		Sedge	Carex vulpinoidea
	Trembling Aspen	Trembling Aspen	*	Mouse-eared Chickweed	Cerastium fontanum
	Hybrid Poplar	Populus x hybrid?	*	Lamb's-quarters	Chenopodium album
	Pin Cherry	Prunus pensylvanica		Cichorium intybus	Chenopodium capitatum
T	Black Cherry	Prunus serotina	*	Chicory	Cichorium intybus
	Choke Cherry	Prunus virginiana		Enchanter's Nightshade	Circaea lutetiana
P	Red Oak	Quercus rubra	*	Canada Thistle	Cirsium arvense
*	Common Buckthorn	Rhamnus cathartica	*	Crown Vetch	Coronilla varia
*	Alder-buckthorn	Rhamnus frangula		Bulblet Fern	Cystopteris bulbifera
PC	Staghorn Sumac	Rhus typhina	*	Orchard Grass	Dactylis glomerata
	Wild Black Currant	Ribes americanum	*	Queen Anne's Lace	Daucus carota
	Prickly Gooseberry	Ribes cynosbati	*	Pink	Dianthus sp
PC	Black Locust	Robinia pseudoacacia	*	Teasel	Dipsacus fullonum
*	Dog Rose	Rosa canina		Marginal Wood Fern	Dryopteris marginalis
	Wild Rose	Rosa blanda	*	Barnyard Grass	Echinochloa crusgalli
*	Multiflora Rose	Rosa multiflora	*	Blueweed	Echium vulgare
	Common Blackberry	Rubus allegheniensis		Bottlebrush Grass	Elymus hystrix
	Wild Red Raspberry	Rubus idaeus		Field Horsetail	Equisetum arvense
	Black Raspberry	Rubus occidentalis		Annual Fleabane	Erigeron annuus
	Flowering Raspberry	Rubus odoratus		Philadelphia Fleabane	Erigeron philadelphicus
*	White Willow	Salix alba	*	Dog Mustard	Erucastrum gallicum
	Peach-leaved Willow	Salix amygdaloides	*	Wormseed Mustard	Erysimum cheiranthoides
	Bebb's Willow	Salix bebbiana		Spotted Joe-Pye Weed	Eupatorium maculatum
	Heart-leaved Willow	Salix eriocephala		Boneset	Eupatorium perfoliatum
	Shining Willow	Salix lucida		White Snakeroot	Eupatorium rugosum
	Slender Willow	Salix petiolaris	*	Leafy Spurge	Euphorbia esula
*	Basket Willow	Salix purpurea		Grass-leaved Goldenrod	Euthamia graminifolia
	Common Elder	Sambucus canadensis		Strawberry	Fragaria virginiana/vesca
	Red-berried Elder	Sambucus racemosa ssp. pubens		Cleavers	Galium aparine
	Meadowsweet	Spiraea alba	*	Herb Robert	Geranium robertianum
*	Common Lilac	Syringa vulgaris		Yellow/White Avens	Geum aleppicum/canadense
PC	Eastern White Cedar	Thuja occidentalis		Fowl Manna Grass	Glyceria striata
	Basswood	Tilia americana		Stickseed	Hackelia virginiana
	Poison Ivy	Toxicodendron radicans		Woodland Sunflower	Helianthus divaricatus
P	White Elm	Ulmus americana		Ox-eye	Heliopsis helianthoides
P	Nannyberry	Viburnum lentago		Canada Waterleaf	Hydrophyllum canadense
P	Highbush-cranberry	Viburnum opulus/trilobum		Virginia Waterleaf	Hydrophyllum virginianum
	Downy Arrow-wood	Viburnum rafinesquianum	*	Prickly Lettuce	Lactuca serriola
	Riverbank Grape	Vitis riparia	*	Tuberous Vetchling	Lathyrus cf. tuberosus
	Herbaceous plant species		*	Motherwort	Leonurus cardiaca
*	Yarrow	Achillea millefolium	*	Field Pepper-grass	Lepidium campestre
	Agrimony	Agrimonia gryposepala	*	Ox-eye Daisy	Leucanthemum vulgare
*	Quack Grass	Agropyron repens	*	Butter-and-eggs	Linaria vulgaris
*	Redtop	Agrostis gigantea		Indian Tobacco	Lobelia inflata
*	Creeping Bent Grass	Agrostis cf. stolonifera	*	Bird-foot Trefoil	Lotus corniculatus
*	Garlic Mustard	Alliaria petiolata		Water-horehound	Lycopus uniflorus
	Common Ragweed	Ambrosia artemisiifolia		Wild-lily-of-the-valley	Maianthemum canadense
	Thimbleweed	Anemone virginiana		False Solomon's-seal	Maianthemum racemosum
	Indian Hemp	Apocynum cannabinum	*	Black Medic	Medicago lupulina
	Wild Columbine	Aquilegia canadensis	*	Alfalfa	Medicago sativa
	Spikenard	Aralia racemosa	*	White Sweet Clover	Melilotus alba
*	Great Burdock	Arctium lappa	*	Yellow Sweet Clover	Melilotus officinalis
*	Common Burdock	Arctium minus		Wild Bergamot	Monarda fistulosa
	Wild Ginger	Asarum candense		Muhly Grass	Muhlenbergia mexicana

Table 3: Colonizing Species Observed on the Rehabilitated Slopes (Continued)

	Common Name	Scientific Name		Common Name	Scientific Name
	Herbaceous plant species				
*	Catnip	Nepeta cataria	*	Nightflowering Catchfly	Silene noctiflora
	Evening-primrose	Oenothera cf.biennis	*	Bladder Campion	Silene vulgaris
*	Marjoram	Origanum vulgare		Blue-eyed Grass	Sisyrinchium montanum
	Wood-sorrel	Oxalis stricta		Carrion-flower	Smilax herbacea
	Witch Grass	Panicum capillare	*	Bittersweet	Solanum dulcamara
*	Wild Parsnip	Pastinacea sativa		Tall Canada Goldenrod	Solidago altissima/ canadensis
	Reed Canary Grass	Phalaris arundinacea		Blue-stem Goldenrod	Solidago caesia
*	Timothy	Phleum pratense		Zig-zag Goldenrod	Solidago flexicaulis
	Common Reed	Phragmites australis		Early Goldenrod	Solidago juncea
*	English Plantain	Plantago lanceolata		Gray Goldenrod	Solidago nemoralis
*	Broad-leaved Plantain	Plantago major		Rough Goldenrod	Solidago rugosa
	Canada Blue Grass	Poa compressa	*	Sow-thistle	Sonchus sp.
	Fowl Manna Grass	Poa palustris		Slender Wedge Grass	Sphenopholis intermedia
*	Kentucky Blue Grass	Poa pratensis	*	Dandelion	Taraxacum officinale
*	Rough Cinquefoil	Potentilla norvegica		Early Meadow Rue	Thalictrum dioicum
*	Rough-fruited Cinquefoil	Potentilla recta		Tall Meadow Rue	Thalictrum pubescens
	Common Cinquefoil	Potentilla simplex/ canadensis	*	Penny Grass	Thlaspi arvense
	White Lettuce	Prenanthes alba	*	Red Clover	Trifolium pratense
	Heal-all	Prunella vulgaris	*	White Clover	Trifolium repens
	Bracken	Pteridium aquilinum		White Trillium	Trillium grandiflorum
	Small-flowered Buttercup	Ranunculus abortivus	*	Coltsfoot	Tussilago farfara
*	Tall Buttercup	Ranunculus acris		Common Cattail	Typha latifolia
	Black-eyed Susan	Rudbeckia hirta		Stinging Nettle	Urtica dioica
*	Sheep Sorrel	Rumex acetosella	*	Common Mullein	Verbascum thapsus
*	Curled Dock	Rumex crispus	*	Common Speedwell	Veronica officinalis
*	Bitter Dock	Rumex obtusifolius	*	Bird Vetch	Vicia cracca
	Black Snakeroot	Sanicula marilandica		Marsh Violet	Viola affinis
	Dogmint	Satureja vulgaris		Canada Violet	Viola canadensis
	Black Bulrush	Scirpus atrovirens		Long-spurred Violet	Viola rostrata
*	Yellow Foxtail	Setaria glauca		Common Blue Violet	Viola cf. sororia
*	Green Foxtail	Setaria viridis		Violet	Viola sp.

* = Exotic to the Regional Municipality of Halton

Modified from Monet, 1998

P = Planted from nursery stock

C = Colonizing

Z = Naturalized in the Regional Municipality of Halton

- birch, red osier dogwood, and virgin's bower.
- violets, trilliums, bellwort, wild ginger, etc. have been found on the forest soils of the west slopes.
- although similar numbers of trees have been planted on both the east and west slopes, nursery stock plantings represent a larger proportion of the relative abundance of woody vegetation on the east slopes when compared to the west slopes. Planted species such as Tamarack (18 %), White Cedar (12 %) and White Spruce (9 %) are as dominant as Sumac (18 %) on the eastern slopes. In contrast, volunteer species such as sumac (up to 74 %), pin cherries (up to 21 %), red osier dogwood (6%), and elderberry (4%) dominant woody vegetation cover on the western slopes. Planted species such as White Cedar (3%), White Spruce (4%), Tamarack (3%) and Silver Maple (1%) account for much less of the woody vegetation.
- average height of the volunteer pin cherries is greater than 2 m after five years.
- although, the first to arrive and most abundant volunteer woody species is staghorn sumac, species such as pin cherry, balsam poplar and elderberry are now as tall or taller than the sumacs (Morris, 1997)
- The majority of the sumac appears to spread from the top of the slopes downwards towards the quarry floor.
- Of the 214 species identified over 9 general rehabilitated areas within the quarry in 1998, 132 of the species (61.7 %) were native. Thirty nine native woody species, not including planted stock and 93 native herbaceous species have been identified.

- exotic herbaceous species are most dominant on the seeded slopes with less desirable soil conditions. Colonization of exotic woody species is low across the site with only 13 species identified.
- to date, 20 woody species and 32 herbaceous species for a total of 177 individuals have been planted in 72 plugs
- further monitoring will continue to substantiate results and determine reasons for variation
- Colonizing species observed on the rehabilitated slopes are listed in Table 3.

Table 4: Bird Species Observed in the Milton Quarry

(Common Loon)	Blue Jay
Great Blue Heron	American Crow
Canada Goose *	Black-capped Chickadee
Wood Duck	House Wren *
Mallard *	American Robin *
Turkey Vulture *	Gray Catbird *
(Coopers Hawk)	American Pipit
(Red-tailed Hawk)	Cedar Waxwing *
Killdeer *	European Starling *
Spotted Sandpiper *	Red-eyed Vireo
Least Sandpiper	Nashville Warbler
Ring-billed Gull	Yellow Warbler *
Rock Dove *	Common Yellowthroat *
Mourning Dove	Rose-breasted Grosbeak
American Goldfinch	Indigo Bunting *
Belted Kingfisher	Chipping Sparrow *
Northern Flicker	Field Sparrow
Willow Flycatcher	Savanah Sparrow *
Great Crested Flycatcher	Song Sparrow *
Eastern Kingbird *	Slate-colored Junco
Horned Lark *	Bobolink
(Purple Martin)	Red-winged Blackbird *
Tree Swallow	Eastern Meadowlark *
Northern Rough-winged Swallow *	Ruby-throated Hummingbird *
Bank Swallow *	Baltimore Oriole
Cliff Swallow *	(Pine Siskin)
Barn Swallow	Eastern Phoebe Flycatcher
	Common Grackle

Modified from Sheppard (1998)

( ) observed flying over the quarry

* confirmed or suspected breeders.

Ornithological Study

To date, 52 species of birds have been observed within the quarry and 4 more flying over head. Of the 53 species, are thought to be breeding within the rehabilitated areas. The first year of study provides baseline data to assess future trends as the rehabilitated slopes and demonstration area continue to evolve. Birds observed throughout the first spring/summer season of study are listed in Table 4. The most interesting result is 52 pairs of nesting cliff swallows on the faces next to the demonstration area.

Discussion

The more recent approach of retaining some of the quarry walls as cliff faces has enhanced the rehabilitation of the quarry. As a result, the landscape now includes cliff faces and a variety of slopes that are more diverse, attractive and a better fit with the surrounding landscape including the escarpment face. The exposed faces provide cliff habitat and already have 52 pairs of cliff swallows nesting (Sheppard, 1998).

In the original rehabilitation of the "gap", plant growth and natural colonization has not been as vigorous as anticipated. The thick mat of grass and compaction from grading have impeded natural succession and the growth rate of the seedlings. Future rehabilitation will include additional treatment to accelerate woody growth on this slope and help close the gap.

Survival and growth of trees and shrubs on the future pond slopes is generally satisfactory. Significant natural colonization by native species is very encouraging. The favorable natural colonization results achieved on the west slopes are thought to be largely the result of superior soil

conditions. The soils were primarily forest floor soils rather than the agricultural soils used to backfill the east slopes.

Some soil amelioration and amendments in the future may be required to enhance the growth and survival of vegetation along sections of the east slope.

The accelerated rate of colonization and higher diversity of species on the west slopes also appears to have been aided by a change in seeding practices. Prior to 1991, all slopes were seeded with a grass mixture to quickly "green up" the slopes and control erosion prior to tree planting. The more recent approach utilizes the seed bank, rich and diverse natural vegetation surrounding the site and dispersion of seeds through wind, wildlife and birds to naturally colonize the slopes. The thick mat of grass species resulting from seeding on the east slopes appear to have impeded natural succession of woody species.

Monitoring natural colonization of the slopes provides an opportunity to evaluate current practices and may lead to new practices regarding species selection and timing of transplanting in relation to the developing vegetation cover. For example, will the shade provided by the early successional woody species such as sumac restrict the growth of planted species or enhance the growth of others? How successful is a diverse landform in producing habitat and species diversity.

The vigorous rehabilitation efforts continue to receive industry recognition for excellence. The quarry has received progressive rehabilitation awards from the Aggregate Producers Association of Ontario each of the last 3 years. The quarry has also received the prestigious "About Face Award" from the National Stone Association recognizing our achievements in rehabilitation throughout North America.

Future Work

The studies currently undertaken to monitor and assess previous rehabilitation strategies will continue to provide useful information to help guide future efforts. As the demonstration area continues to develop, it will provide a valuable example of the future land use anticipated for the remainder of the quarry. Additional lessons can be applied to future rehabilitation throughout the quarry.

Dufferin Aggregates will continue to foster partnerships with universities and colleges to study and improve rehabilitation techniques and monitor results. The Company was a recent partner in a NSERC Scholarship with a University of Guelph Masters student who studied the successful use of pond fines in rehabilitation. Dufferin will also continue to explore the potential for developing new partnerships in the future with agencies interested in applied research to enhance the knowledge, practices and success of rehabilitation, habitat enhancement, fisheries establishment, and natural succession, seed rain, biodiversity and biosphere monitoring.

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Abstract Submission
To
The Society for Ecological Restoration - Ontario Chapter
and
The Canadian Land Reclamation Association

Practical Considerations and Lessons Learned in the Reclamation/Restoration of Habitat as a Component of Site Development

This paper will explore the practical considerations and lessons learned in the reclamation/restoration of habitat as a component of site development. The discussion will be initiated with generalized information progressing to a more detailed and technical discussion of the use of the BioMAP technique to improve the reclamation/restoration effort.

There is an increasing interest in, and opportunity to, incorporate reclamation and restoration activities into development and redevelopment projects. However, this presents a variety of challenges, not the least of which is convincing the developer of the benefits of doing so.

The benefits to the developer of incorporating restoration into a development proposal include:

- greater acceptance of the project by the public and approval agencies
- using the net gain approach to obtain approvals for a project which might otherwise be unlikely to proceed
- public relations and promotional potential
- aesthetic considerations

For example, we recently worked on a project involving a major mall expansion. The mall was serviced by inground sewage systems which occupied a substantial acreage of valuable commercial land. This land could be "freed up" for commercial development and parking by putting in place a sewage treatment plant discharging to surface waters. In exchange for receiving approval to do so the developer agreed to retrofit the mall with stormwater quality control as well as improve an existing wetland and create new fish habitat on site. Although the developers primary motivation related to obtaining development approvals, the potential public relations were quickly realized with plans to introduce interpretive trails and a brochure describing the restoration and habitat creation efforts.

Once the developer has been convinced of the benefits of incorporating restoration works into the project, the challenges have however only begun. Some of the considerations and problems we have encountered include:

- the sensitivity of the project engineers to your objectives and the techniques utilized
- the contractor's experience, or lack thereof, and understanding of your objectives
- timing of construction activities in relation to biological considerations
- the lack of information concerning techniques for particular habitats or species
- lack of familiarity by the approval agencies with the restoration techniques
- acceptability by municipal representatives
- lack of biological and physical materials to accomplish the job
- unexpected and detrimental site conditions, particularly on previously developed sites
- effectively targeting and monitoring success of restoration/rehabilitation efforts

On this latter point we have recently increased our use of a particular technique for aquatic ecosystems. This technique is the BioMAP program which has the following advantages:

- determining system health and establishing priorities
- utilizing existing data basis to establish a historic or potential performance level
- monitoring the success of the restoration effort

As a biological assessment and monitoring tool BioMAP has a number of strengths. The assessment of stream or shoreline health is based on the living community, rather than a sub-set of indicator species or chemical/physical parameters. As a group, benthic invertebrates are excellent indicators of water and habitat quality because they are relatively long lived, sedentary and are subject to the full rigor of environmental stresses throughout their life cycles. BioMAP indices are sensitive to change, they exhibit little seasonal variation, and are therefore excellent tools for establishing baseline or "benchmark" conditions and monitoring trends over time. A multi-metric approach can be applied to determine the nature of factors that are acting in concert to shape the living community of the stream or shoreline.

These strengths make BioMAP a valuable tool in the restoration/reclamation of aquatic ecosystems.

Michael Wynia, MCIP, RPP, Partner
Krystawyn Environmental Consulting
Box 79, NewLowell, Ontario
L0M 1N0

705-424-2871

Chris Jones, B.Sc.
Chris Jones Biological Monitoring
R.R.#1 Schomberg, Ontario
L0G 1T0

905-936-5547

AGGREGATE SUPPLY TRENDS AND RECLAMATION OPPORTUNITIES

by James D. Parkin, B.E.S., M.C.I.P., R.P.P.
MacNaughton Hermsen Britton Clarkson Planning Limited
for Reclamation and Restoration of Settled Landscapes
CLRA/SER Conference - September 1998

ABSTRACT

The majority of the Greater Toronto Area aggregate production comes from the Niagara Escarpment Plan Area or the Oak Ridges Moraine. Both of these areas are highly regarded for their environmental and recreational values. Planning for the continuing supply of essential non-renewable aggregate resources must be sensitive to the environmental and recreational attributes of these close to market supply areas. Ecologically orientated rehabilitation plans are an important component of this planning exercise. Well planned extraction in conjunction with good progressive rehabilitation can provide opportunities for ecological enhancement and community benefits.

The paper will outline some of the general trends affecting aggregate resource planning and highlight recent projects which emphasize ecological restoration and community benefits.

The author is a consulting resource planner with 15 years of experience in the field. This includes both broad policy issues and detailed site specific approvals and design. The author is also a member of the Canadian Land Reclamation Association and Past President of the Ontario Chapter.

THE IMPORTANCE OF CLOSE TO MARKET SUPPLY AREAS

Provincial policy and sound planning principles dictate that aggregate be supplied from close to market locations. Mineral aggregates are characterized by their high bulk and low unit value. The economic value of a deposit is a function of its proximity to the consumer as well as its quality and size. The importance of being "proximate" is directly related to the impacts of truck haulage which is estimated to account for 60% of the cost. In addition to economic advantages, use of close to market resources brings with it significant social and environmental benefits associated with reduced truck haulage. This explains the "close to market" component of Provincial Policy.



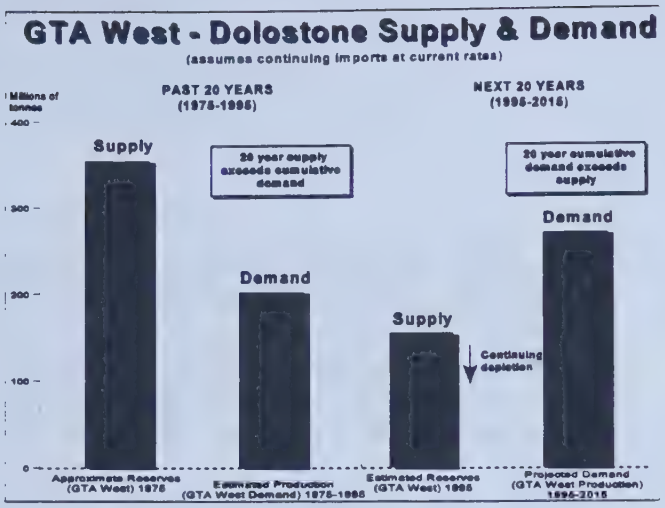
Ontario will need an estimated 3.5 billion tonnes of aggregate over the next twenty years. That is about 100 million truck loads. The distance travelled should be minimized to the greatest extent possible if environmental impacts are also to be minimized. The consequences of increased haul distance simply reflects the reality that trucks haul the aggregate from the deposit to the consumer and the further trucks have to travel the greater the impact on people along haul routes and on the environment in terms of fossil fuel consumption and emissions.

"As much of the mineral aggregate resources as is realistically possible will be made available to supply mineral resource needs, as close to markets as possible."[1]

"As far as it is reasonably possible to do so, each municipality should try to satisfy its need for aggregate from within its own boundaries. That is not only fair, it is government policy, and, in the public interest because the shorter the distance to transport the gravel, the lesser the costs to the consumer."[2]

In Ontario, the most significant market area requiring delivery of close to market aggregate is the Greater Toronto Area (GTA). It is estimated that the GTA consumes 40-65 million tonnes per annum or about one third of the total provincial production.

Over the past 25 years, aggregate supplies in the GTA have been consumed at rates which greatly exceed the replacement of licensed reserves through the issuance of new licenses. Provincial studies have concluded that there is a critical need for new licensing.



Source: MHBC Planning Limited/Clayton Research, 1998

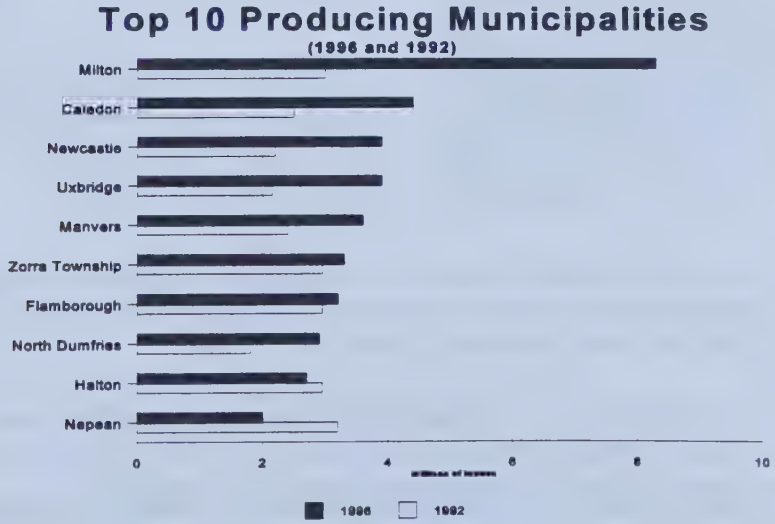
GTA Close to Market Supply Comes From The Oak Ridges Moraine and Niagara Escarpment Plan Area

Aggregates are fixed location, non renewable resources. They can only be extracted in those areas where they occur. The key close to market areas for the Greater Toronto Area are:

1. The Niagara Escarpment Plan Area which includes both important sand and gravel deposits and provincially significant Amabel/Lockport Dolostone (which forms the caprock of the escarpment).

2. The Oak Ridges Moraine which contains large, good quality, sand and gravel deposits.

The GTA (and provincial) dependence on these supply areas is reflected in municipal production statistics. The top five producers (Milton, Caledon, Newcastle, Uxbridge, Manvers) all rely on aggregate deposits in the Oak Ridges Moraine and Niagara Escarpment Plan Area. 75% of GTA aggregate production comes from these two areas.



Source: Mineral Aggregates in Ontario, Overview and Statistical Update, 1992 and 1996, MNR, 1994 and 1998 respectively

The Oak Ridges Moraine (ORM) and Niagara Escarpment Plan Area share a number of general attributes and characteristics that must be taken into account in planning for continued aggregate supplies. These attributes and characteristics can be summarized as three-fold:

- **Environmental attributes:** Both the Niagara Escarpment Plan Area and the Oak Ridges Moraine are provincially recognized environmental resources. This history and geographic conditions in these areas contribute to their environmental sensitivity. Both areas provide significant wildlife habitats, contain concentrations of threatened, rare and vulnerable species and fulfil important hydrogeological functions. Both areas also include less sensitive environmental lands that are within the planning jurisdictions due to their association or proximity to other features.

- **Recreational attributes:** The extensive greenspace and proximity to urban areas means that both the Niagara Escarpment Plan Area and the Oak Ridges Moraine are subject to significant recreational pressures. The provincial interest in these areas is, in part, based on their recreational/greenspace values.

  Planning objectives for the Niagara Escarpment Plan and Oak Ridges Moraine both reflect these environmental and recreational attributes:

- The proximity of these resource areas to urban centres also brings with it the reality of **pressures for residential development.** People wish to enjoy the benefits of City life while living in the Country side. These landforms are generally outside the prime agricultural areas and their scenic qualities contribute to their desirability as a place to live.

  Demographers are predicting a significant movement back to rural areas. It has been termed the "rural population turn around" or "counter urbanization". The "Popcorn Report" calls it "eco-settling". David Foot observes that as people get older they want out of the City. This trend will be heightened by the communication revolution and the home office phenomenon.

These attributes and characteristics are reflected in the Provincial Plans and Policies that apply to these areas:

Introduction - The Niagara Escarpment Plan

The particular combination of geological and ecological features along the Niagara Escarpment results in a landscape unequalled in Canada. It is also a source of some of southern Ontario's prime rivers and streams and one of the province's principal outdoor recreation areas.

OBJECTIVES

The objectives of the Plan are:

1. to protect unique ecologic and historic areas;
2. to maintain and enhance the quality and character of natural streams and water supplies;
3. to provide adequate opportunities for outdoor recreation;
4. to maintain and enhance the open landscape character of the Niagara Escarpment in so far as possible, by such means as compatible farming or forestry and by preserving the natural scenery;
5. to ensure that all new development is compatible with the purpose of the Plan;
6. to provide for adequate public access to the Niagara Escarpment; and
7. to support municipalities within the Niagara Escarpment Plan Area in their exercise of the planning functions conferred upon them by the Planning Act.

1.4 Significance and Sensitivity of the Oak Ridges Moraine

The Moraine provides a wide range of environmental functions critical to the maintenance of healthy water resources and natural heritage values in the Greater Toronto Area.

The Moraine is an important feature for the long term protection of many of the watercourses in the GTA. The north and south slopes of the Moraine are dotted with various springs and wet depressions that are the source areas that provide baseflow to many streams and rivers.

The Moraine, in general, serves as a large recharge area supplying water to a system of aquifers. Many communities and farm operations within the Oak Ridges Moraine depend on these aquifers for their water needs. As can be appreciated, the disruption of the quantity and/or quality of the groundwater resource could have major ramifications.

The Moraine also contains a large number of significant natural areas (e.g. wetlands, fish and wildlife habitat) and large healthy forested tracts. In addition, soil type and topography render many areas of the Moraine sensitive to the forces of wind or water erosion.

The significance and sensitivity of such areas must be taken into account in considering any land use change to ensure the environmental and social benefits of the Moraine are not destroyed or degraded. Therefore site specific and cumulative impacts of planning and development must address the sensitivity and significance of the Moraine.

Implementation Guidelines - Provincial Interest on the Oak Ridges Moraine
Area of the Greater Toronto Area, June 1991

In summary, there is a strong need for continuing and new/replacement supply from the close to market aggregate sources for the Greater Toronto Area. The challenge is to satisfy this requirement with proper regard to the characteristics and attributes of these supply areas. The remainder of this paper considers various approaches and strategies that are being implemented to address these challenges.

ENVIRONMENTAL RESPONSES

Avoidance Strategies

In terms of Environmental Protection, both the Niagara Escarpment Plan and guidelines for the Oak Ridges Moraine identify areas where aggregate extraction (and most other forms of development) are not permitted. This avoidance strategy protects the most sensitive and valuable environmental components of the planning areas.

Protection Strategies

Due to the nature of these resource areas, access to the aggregate resource often means extraction in proximity to significant environmental features. Provincial legislation and planning policy requires that the features be protected from undesirable impacts associated with aggregate extraction. This is achieved through detailed and comprehensive study and an understanding of the impacts of extraction in each specific setting. Mitigation is developed to protect adjacent features and functions.

Restoration and Enhancement Opportunities

Aggregate extraction is an interim land use and rehabilitation of extraction sites provides the opportunity to create afteruses that maximize biodiversity and increase ecological values.

Memories are short. Many who relocate to an area see the pits and quarries and hear how they have been active for many years. There is skepticism in terms of both quantity (rate of) and quality of past reclamation efforts.

Recent land use history on both the Niagara Escarpment and Oak Ridges Moraine provides us with undisputable proof that extraction sites are readily reintegrated with the natural environments which surround them. Aggregate extraction and other man induced disturbances are part of the history and heritage of these land forms.



The first mine in Canada at the Forks of the Credit 1886, limestone and sandstone were extracted.

"A drive up the Niagara Escarpment to the Belfountain is a popular country outing. This charming landscape at the Forks-of-the-Credit is the product of industrial dereliction. Those scenic, jagged, rock piles were waste dumps from late nineteenth-century stone quarries. The birch trees are recent colonists on the steep slopes. The deep cutting through which the road climbs was formed from mining activity. The rustic dam in the Credit River once provided power for local industry. And that is just what you see from the car. If you know where to look vertical quarry faces, rusting wire rope, vestiges of roads and railways, and abandoned derricks. Belfountain was anything but a cherished landscape a century ago. Time and natural regeneration modified the wasteland into an appreciated resource of today."[3]



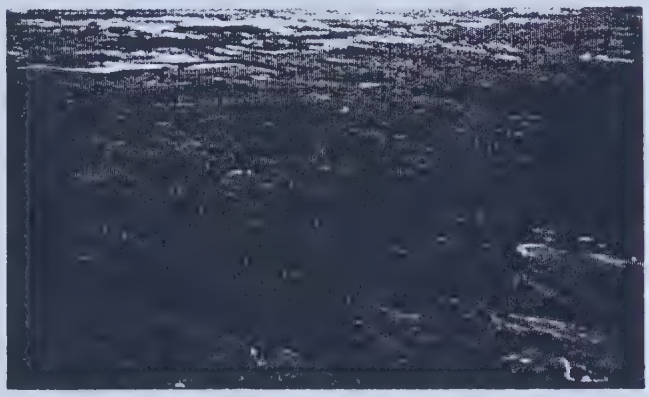
Credit Valley today, looking north to Cataract

The history of land use on the Oak Ridges Moraine is testimony to man's ability to work with nature to repair previous damage. Portions of the Moraine were once a veritable waste land as a result of uncontrolled forestry and agriculture in the 1800's. These same areas, reforested in the mid 1900's, are now part of the Ganaraska Forest, a revered core area of the moraine.

The success of a 1950's reforestation program which turned a denuded landscape of blow sands into a core area forest should leave no doubt that today's aggregate industry with more sophisticated knowledge and stringent regulations can accomplish equal or better results.



Reforestation during the 1940's



Ganaraska Forest today

The Ontario Ministry of Natural Resources has undertaken research which shows that even old extraction sites left to naturally regenerate have become diverse and highly valued ecological refuges. It is recognized that aggregate extraction has an important role in maintaining a mix of landscapes, habitats and species and providing conditions for unique plant and animal communities. Former extraction sites have redeveloped into Class 1 wetlands, valuable fisheries habitat and Areas of Natural and Scientific Interest.

Many of the presentations at this conference further attest to the environmental opportunities.[4]



Rehabilitation at Dufferin Aggregates Milton Quarry incorporates slope and habitat diversity



Progressive rehabilitation at the Halton Crushed Stone Quarry near Campbellville has provided an excellent variety of slopes and vegetation diversity.

Monitoring Opportunities

Monitoring opportunities are well exemplified in the functions of the UNESCO Biosphere Reserve. The Niagara Escarpment Plan Area is designated as a United Nations Biosphere Reserve. One of the main functions of the reserve is to provide sites for research, monitoring, education and training directed towards local or regional issues of conservation and resource use.[5]

Historical quarry sites provide opportunities to inventory and assess natural regeneration capabilities. Existing operating sites provide opportunities to observe the form and function of adjacent woodland and wetland communities. New extraction sites which have been the subject of detailed environmental studies provide baseline data and opportunities for continued monitoring over the development life of the site. The assembly of this type of information can only improve understanding of impacts and opportunities and improve decision making and mitigation design in the future.

RECREATION RESPONSES

One of the reasons for protection of green space associated with the Niagara Escarpment and Oak Ridges Moraine is to provide a setting for recreation and tourism. Indeed, public support for continued protection of these areas can only be strengthened if they are accessible and available for enjoyment, relaxation and education.

Attributes of extraction sites which make them ideal candidates for recreational redevelopment include:

- The sites are easily accessible. They are close to market/urban areas and have established transportation routes.
- Many extraction sites include water amenities as a result of below water extraction. These sites are very suitable for higher intensity recreational uses (swimming, beaches, water sports).
- It makes sense to use former extraction areas as public access points. Use of a former extraction site avoids the need to disturb "greenfield" sites to provide parking or day use facilities.
- Aggregate companies have shown a willingness to allow some public access to rehabilitated and unused portions of their properties for community recreational pursuits.



Boy Scouts participate in tree planting at Dufferin Aggregates Milton Quarry.



Hikers on Bruce Trail Bridge at Dufferin's Milton Quarry.

There is also a high interpretive/educational value associated with public access to these former extraction sites. They provide an ideal setting for geological study or interpretive centres as well as highlighting industrial and commercial heritage of local areas. For example, Dufferin Aggregates Milton Quarry includes an interpretative lookout on the Bruce Trail which overlooks the quarry and includes a display information regarding geology and history of the site. Dufferin Aggregates has also produced a brochure "Fossils at the Milton Quarry" which is available to visiting groups interested in geological research.



Royal Ontario Museum Family Affair Tour shows off their fossil discovery

COMMUNITY RESPONSES

Aggregate extraction is a rural activity that is dependant on the fixed location of the resource. The land use priority in rural areas is necessarily placed on resource based activities like agriculture, aggregate extraction and recreation (Ontario Provincial Policy Statement, Section 1.1.1 b)).

As planners, we tend to place the priority on rural areas as resource areas. Whether it is agricultural soils or aggregate deposits or environmental resources, they take priority over rural non-farm residential development. This is reflected in Provincial Policy and is the basis for many Ontario Municipal Board Decisions on rural resource uses.[6]

Planning strategies are designed to avoid conflict by restricting rural residential uses in areas where they may preclude or hinder existing or future aggregate extraction (Ontario Provincial Policy Statement Section 2.2.3.3).[6]

In situations where some degree of conflict cannot be avoided (due to existing residential uses), then the aggregate extraction operation is designed to ensure that impacts related to noise, dust, vibration and traffic are controlled so that provincially defined levels and limits are met and the two uses can co-exist.

In some cases, involvement of the community or local residents in the design and monitoring of the operation goes a long way to alleviating concern and developing compromise. The following case study is one such example. In other cases, resident liaison committees have proved useful and have lead to the development of mutually acceptable solutions.

> *One of the license conditions requires the establishment of a Citizens' Advisory Committee comprised of residents adjacent to the quarry and to the haul route for the purpose of reviewing operations at the site and screening complaints regarding site operation and haul route usage..... The Board, based upon the evidence it heard, finds that quarry operators today, are very concerned with the public that is affected by its operations and make every effort to develop and retain good public relations.*[7]

CASE STUDY: INDUSTRY AND COMMUNITY CO-OPERATION LEADS TO ECONOMIC ENVIRONMENTAL, AND SOCIAL BENEFITS

There are many examples of projects that exemplify strong community involvement, environmentally beneficial reclamation and recreational opportunities. A recent example in the Town of Caledon combines many of these elements.

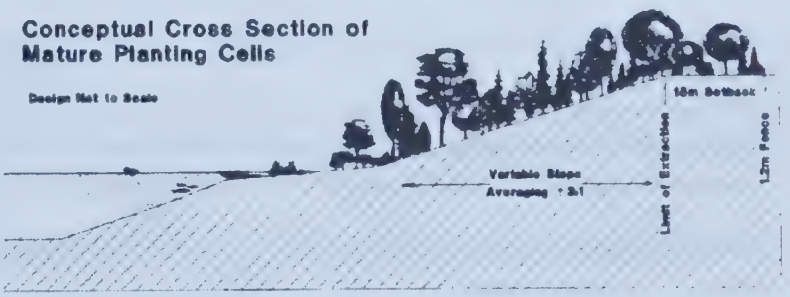
Caledon Sand & Gravel Inc. is located just south of Caledon Village on the edge of the Niagara Escarpment Plan Area within the west end of the Greater Toronto Area. The company is part of the James Dick Construction Group. The pit has operated on a 130 hectare site since 1956. Applications for an 80 hectare (200 acre), 35 million tonne, expansion were initiated in the late 1980's. The original application met with vehement opposition from local politicians and area residents.

While the existing pit is outside the Niagara Escarpment Plan Area, the extension lands were located in the Plan Area. There is a provincially significant wetland to the north (partially within the existing licensed pit). The pit area is also a recharge zone for the regional aquifer which provides baseflow to springs and tributaries which contribute to significant fisheries resources.

As a result of several fortuitous circumstances including pre-hearing mandated negotiations, the applicant, review agencies and public were able to narrow and eventually resolve concerns regarding the proposed pit extension. The settlement, negotiated in 1996, was achieved by making significant alterations to the extraction and rehabilitation proposals.

The basis for the settlement was detailed, comprehensive environmental studies and investigations which provided a good understanding of surrounding environmental features and their relationship to important environmental functions. For example, the hydrogeological studies lead to recommendations for installation of a hydraulic buffer around the provincially significant wetland in order to reduce potential drawdown impacts associated with underwater extraction.

Another key was the development of an augmented rehabilitation plan incorporating ecological enhancement principles which was developed in order to improve connectivity of adjacent environmental areas. One of the objectives of the ecological enhancement rehabilitation plan is to establish and promote biologically diverse indigenous plant communities. Planting cells are designed to provide both age and species diversity which will provide multiple habitat opportunities for a wide range of wildlife species.



Source: Ecological Services for Planning

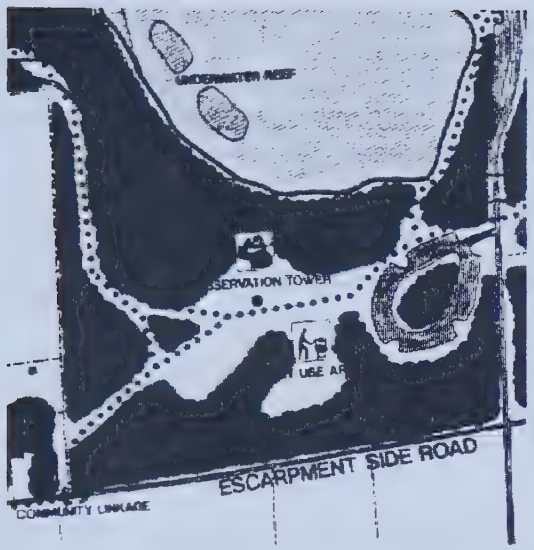
The overall net effect of the expansion proposal was maintenance and enhancement of ground and surface water resources. This includes a small increase to the baseflow of adjacent creeks which is viewed as beneficial both from a hydrogeological and ecological perspective. A detailed monitoring regime is in effect to track the accuracy of the predictions and contingency plans are included in the event that adjustments are required.

In addition to these environmental achievements, the community secured a number of operational and rehabilitation commitments that addressed their concerns.

- The operational phasing was revised in order to accelerate extraction and rehabilitation of areas closest to Caledon Village thereby making them available for alternative uses in a shorter timeframe.
- The applicant also agreed to construct a community beach at the north end of the operation as well as providing associated trail and future wetland areas.



Community Beach and Trails



Proposed Bruce Trail and Observation Tower

- At the south end of the property, the applicant agreed to allow realignment of the Bruce Trail to allow hiking access to the southern buffer lands. This commitment includes an agreement to provide a location for access, parking spots, interpretive displays and observation points. Over time, it is expected that this access and co-operation will extend to other portions of the property.

As a result of the negotiated settlement, the applicant was able to secure access to additional resources which were critical to both the corporation and provincial consumers. The site had immediate access to provincial highway in close proximity to the growing urban areas in the Greater Toronto Area.

In addition to these tangible benefits, an additional achievement was the establishment of a good working relationship between the applicant, residents and the municipality.

CONCLUSION

Close to market aggregate supply areas for the Greater Toronto Area are the Niagara Escarpment Plan Area and Oak Ridges Moraine. Extraction in and adjacent to this area must be carefully planned to realize opportunities such as environmentally beneficial restoration, recreational focal points and community benefits.

ENDNOTES

[1] Ontario Provincial Policy Statement 2.2.3.1

[2] Floyd Preston Limited License Application (Town of East Gwillimbury), April 23, 1990, Board File Nos. O 870050 et al., A.J.L. Chapman, Vice-Chair and C.M. Millar (Re)

[3] Andreae, Christopher. "Industry, Dereliction, and Landscapes in Ontario." Ontario History LXXXIX.. 2 (June 1997), 162-180

[4] See for example, Abandoned Pits and Quarry Sites: Living Experiments (Mark Browning), Management of Abandoned Aggregate Properties Program, Chris McGuckin, Landscape Ecology Approaches to Sustainable Management of Mineral Aggregate (John Fraser), Rehabilitation of the Glenridge Quarry Landfill Site, (J. Fausto), Planning for the Future: Rehabilitation of Dufferin's Milton Quarry, (Ken Zimmerman), A Natural Heritage Approach to the Rehabilitation of Southern Ontario's Pits and Quarries (Ken Ursic)

[5] Biosphere Reserve: What Does It Mean? George Francis, Member - Working Group on the Biosphere Reserves.

[6] See for example, Rideau (Township) Official Plan Amendment (Dibblee Construction), August 25, 1983, Board File No. R 821749 et al., D. M. Rogers and J.E. Hendy (Re), Pages 2 and 4, Lafarge Canada Inc. Class A License (Township of Camden East), September 26, 1997, Board Files Nos. Z920054 et al., T. Yao (Re)

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CONTROL OF THE INVASIVE DOG-STRANGLING VINE Cynanchum rossicum

Stephen Smith, Project Manager

Urban Forest Associates

ABSTRACT

Dog-strangling vine *Cynanchum rossicum* is an exotic twinning perennial vine which has recently become invasive in southern Ontario and central New York state. It can be found in abundance within the Toronto area and is spreading quickly along road, hydro, and rail corridors. Although it is an important threat to native vegetation, especially on disturbed sites, no research has been undertaken to determine the plants' phenology or methods to control its spread. In 1996, we undertook field studies to determine the plant's life cycle, reproductive capacity, and methods to control its spread.

This presentation will discuss the results of the study and recommend the most effective control measures.

Introduction

The recent proliferation of dog-strangling vines (*Cynanchum* [=*Vincetoxicum*] *spp.)* is posing a serious threat to southern Ontario's flora. These perennial members of the milkweed family, also known as swallow-worts, can reach a length of 2 metres and produce copious amounts of wind-blown seed. If present in sufficient densities, the plants intertwine and create an impenetrable tangle that shades out other species of open fields and open forests.

To date, there has been very little published information on the ecology of dog-strangling vines in Canada or Europe. Gaining an understanding of the reproductive biology of these plants in southern Ontario is an important first step in the design of effective control programs. For this reason, a phenological study of the most invasive of these species, *C. rossicum*, was undertaken between June and October of 1996, concurrent with the control study.

The control study was undertaken to assess the potential value of mowing, light blockage (involving the use of plastic sheeting to cover plots) and herbicide treatments in reducing the presence of *C. rossicum* in a dense infestation. Specifically, the study was designed to determine the effects of timing and the number of treatments on percent cover of *C. rossicum* one year later.

Methods

Control studies were conducted in Morningside Park, located in the Highland Creek valley in Toronto, Ontario. The park consists of degraded upland forest, conifer plantings, mowed turf and successional fields. A 1200 m^2 area of open field dominated by *C. rossicum* was selected for study. The site is on a south-facing terrace with a 7% slope. Soils are sand loams and loamy sands of variable thickness overlying glacial till. Poor drainage, caused by a compacted Bc layer, is indicated by subsoil mottling.

Other vegetation present on the site included riverbank grape [*Vitis riparia* Michx.], wild red raspberry [*Rubus strigosus* (Michx.], goldenrods (*Solidago spp.*), cow vetch [*Viccia cracca* (L.)], grasses (*Agrostis, Bromus, Phleum spp.*) and other herbaceous species. The study area is bordered by a disturbed forest edge of white spruce [*Picea glauca* (Moench) Voss], Scots pine [*Pinus sylvestris* (L).] and staghorn sumac [*Rhus typhina* (L.)].

A simple block design was used to randomly assign 13 treatments consisting of three replicates each, and one control plot. 4 m^2 plots were marked with wooden stakes in each corner. Treatments (Table 1) consisted of 1) mowing with a rotary mower 5 cm above the ground, 2) covering plots with opaque plastic sheeting and 3) treating plots with a 5% solution of the herbicide glyphosate. All treatments were carried out in 1996.

Mowing treatments included a single mow in mid-June, early August and late August and repeated mows in mid-June, early and late August and in early and late August. Three plots were mowed in mid-June and covered with black plastic sheeting secured by metal pins. The sheeting was intended to suppress growth by blocking light. Herbicide treatments were timed to correspond with mowing treatments, with the exception of the late August application, which was delayed until early September.

Four circular sample plots (1.12 m diameter, 1 m^2 area) were randomly established within each of the 37 square treatment plots. Percent cover of all vegetation in the sample plots was visually estimated on June 18, 1996 to a total of 100%. The average standing height of *C. rossicum* was also recorded in the control and mowed plots. Plots were resampled on June 21, 1997 to determine the effects of different treatments on percent cover of *C. rossicum* the following year. Control is expressed as the percent reduction of cover from initial estimates, and is summarized in table form. Other data and relevant observations are descriptively reported.

Effects of Treatment on Reproduction: Nine root systems were excavated in August, 1997 from plots treated three times with glyphosate. The roots were then potted for observation to determine whether growth could resume following herbicide damage to perennating tissues.

Seed produced in treated plots in 1996 was collected and tested for viability. After three months of dry storage at 4° C, 28 seeds were selected from each treatment and germinated at temperatures averaging 21° C. Seeds were germinated by placing them on top of soil in plastic trays. Viability was tested in the same manner in 1997. In this trial, fifty seeds were selected from each treatment and germinated after one month of dry storage at 21° C.

Table 1. Manual and herbicide treatments applied to *C. rossicum*.

Treatment	Description	Time of Application(s)	Replications
1	Control plot	------	1
2	Mowing (x3)	June, early & late August	3
3	Mowing (x2)	early & late August	3
4	Mowing	June	3
5	Mowing	early August	3
6	Mowing	late August	3
7	Herbicide (x3)	June, ear. Aug.,ear. Sept.	3
8	Herbicide (x2)	June, early August	3
9	Herbicide (x2)	June, early September	3
10	Herbicide	June	3
11	Herbicide	early August	3
12	Herbicide	early September	3
13	Light blockage	June	3

Results

Mowing: As Table 2 shows, mowing did not cause a significant reduction in percent cover of *C. rossicum* the following year. Percent cover varied between 75 and 86% after different mowing treatments, and fell within the range of values for the control plot in 1996 (75%) and 1997 (86%). Reductions of up to 13%, and increases of up to 6% were observed, although there was no consistent pattern of increase or decrease. Mowing had a visible effect on average height, however (with the exception of a single mow in early August). The average height of vines declined by as much as 28 cm (46%) after mowing, although no relationship between height and number of treatments was apparent. Seed set was observed in all mowed plots in 1997, and seed viability was confirmed by subsequent germination studies.

Table 2. Mean percent cover reduction/increase of *C. rossicum* one year after mowing, herbicide and light blockage treatments.

Treatment	Time of Application	Percent cover reduction (↓) or increase (↑)
Control	------	------
Mowing (x3)	June, early & late August	13% ↓
Mowing (x2)	early & late August	5% ↑
Mowing	June	6% ↑
Mowing	early August	8% ↓
Mowing	late August	10% ↓
Herbicide (x3)	June, early Aug., early Sept.	97% ↓
Herbicide (x2)	June, early August	97% ↓
Herbicide (x2)	June, early September	92% ↓
Herbicide	June	59% ↓
Herbicide	early August	85% ↓
Herbicide	early September	57% ↓
Light blockage	June	------

Light Blockage Treatments: The plastic sheeting was repeatedly torn open by skunks and other animals, allowing cover of *C. rossicum* to return to 85% (compared to 96% in 1996) by June of 1997. While intact and secure, the plastic sheeting suppressed the growth of the plants.

Herbicide Treatment: Prior to treatment, *C. rossicum* comprised 71 to 95% of the total cover in herbicide plots, compared to 75% in the control. All herbicide treatments reduced cover values, regardless of the number of treatments or timing of application (Table 2). Single treatments of glyphosate were less effective than multiple applications. A single treatment in mid-June reduced cover from 75% in 1996 to 31% in 1997 (a reduction of 59%). Cover declined to almost the same extent following treatment in early September, from 72% in 1996 to 31% in 1997 (a reduction of 57%). Treatment in early August resulted in the strongest reductions in *C. rossicum*, from 82% in 1996 to 12% in 1997 (a reduction of 85%).

Multiple treatments in mid-June and early August and in mid-June, early August and early September provided excellent control in 1997 (Table 2). In both cases, cover declined to only two and 3% in 1997, from pre-treatment values of 71% and 93% respectively (reductions of 97% in both cases). An application of glyphosate in mid-June and early September also sharply decreased cover values from 95% in 1996 to 8% in 1997 (a reduction of 92%).

Following single treatments with herbicide in 1996, some stems, although top-killed, remained yellow-green until the end of the summer. The dense, intertangled foliage made treatment of the lower layers of vegetation difficult. Although most growth in 1997 was from seed, a few mature plants managed to regenerate in plots which received one or two applications of glyphosate.

Root excavations revealed that *C. rossicum* may persist below ground without giving any aboveground indications of its survival. Triple applications of glyphosate had a devastating effect on root systems, which had largely disintegrated, leaving a rotted root crown. In spite of extensive damage, several of the root crowns examined had white, living buds which turned green after watering and exposure to light. Of the nine crowns potted in soil, two produced aerial shoots in 1997. After four months these plants were only 2 cm tall, but had roots up to 7 cm in length. A new "crown" had developed, and the older, damaged tissues had completely necrotized.

Plants which regenerated from established root systems were able to produce normal fruit with viable seed in 1997. No seed was produced in plots treated three times, since no aerial shoots were present in 1997, and because seedlings did not mature to the reproductive stage. Seed set was observed in 1996 following single applications of glyphosate in early August and early September. Treatment in early August accelerated the process of seed development, which enabled plants to release seed before succumbing to the herbicide. Treatment in early September also had a catalyzing effect on dispersal, which had begun in the control plot at this time.

Seed obtained from herbicided plots in 1996 appeared small and shriveled when compared to seed from untreated plants. Not surprisingly, germination was 0%, compared to 30% for the control and 40% for plants mowed only in mid-June. Lower germination rates were obtained for the control in 1997 (15%), however, 44% of the seed collected from plots treated with herbicide only in mid-June germinated without stratification.

A dramatic shift in species composition was observed in herbicided plots in 1997. Sweet white clover [*Melilotus alba* (Medikus)] replaced *C. rossicum* as the dominant species in most plots, and became especially abundant after treatment in early August and in mid-June and early September. Total cover of sweet white clover ranged from 22 to 71% between treatments and reached 87% in one plot. The sudden proliferation of this species is of interest since it comprised a very low percentage of total cover where it occurred in 1996. Several other exotic plants including bull thistle [*Cirsium vulgare* (Savi) Ten.], common mullein [*Verbascum thapsus* (L.)], curled dock [*Rumex crispus* (L.)], charlock [*Brassica kaber* (L.)], rough bedstraw [*Galium asprellum* (Michaux)] and St. John's wort [*Hypericum perforatum* (L.)] formed conspicuous patches on bare soil. These species comprised a lower percentage of total cover in 1996 or were not recorded on the study site. Cow vetch, riverbank grape, grasses and goldenrods declined to a small degree in 1997 when compared to 1996 cover values (data not given).

Discussion

Of the methods tested, herbicide treatments provided the most effective control of *C. rossicum* in the short-term. Glyphosate had a dramatic impact when compared to mowing, which had no significant effect on cover. Although mowing diminishes growth, it is unlikely that an additional year of treatment would be sufficient to exhaust stored carbohydrate reserves. The extensive, fibrous root system of this species may enable it to survive several years of top growth removal. Hodgson (1968 - in Evans 1984) found that four years of repeated mowing was necessary to reduce Canada thistle [*Cirsium arvense* (L.) Scop.] another invasive perennial, to 1% of its initial value. Over the longer-term, mowing may have value as an environmentally benign, but labour-intensive form of controlling *C. rossicum*.

Although plastic sheeting was not successfully used to control *C. rossicum* in this study, this method may hold promise. While intact and secure, the plastic sheets effectively suppressed growth, which did not resume until openings in the sheets were created. This observation suggests that if more durable material had been used, and steps taken to more firmly anchor it, the trial may have yielded positive results. In a similar experiment, Ambrose (1996) reported the near complete elimination of *C. rossicum* (aboveground) after covering a plot with plastic sheeting for one year.

The greatest reductions in *C. rossicum* were observed after repeated applications of glyphosate. The results of this study indicate that two or more treatments may be required to achieve a high degree of control within one year. The lack of difference between treatments in June and early August and June, early August and early September suggests that a third treatment in September had no further effect on reducing cover. A third application may be of added benefit, however, since no regrowth of adult plants was observed in plots treated in early September.

Single treatments may have been less effective than repeated treatments for several reasons. As mentioned earlier, the rank, tangled growth of the vines made even application of the herbicide difficult. This factor undoubtedly contributed to higher regrowth in plots treated once (some top-killed stems even produced fruit if flowers were missed on lower cymes). Single treatments may be less injurious to roots, and allow quicker recovery and resumption of growth. The results of the root potting trial suggest that seedlings may have had sufficient time following treatment in mid-June, and possibly early August, to become established and produce perennating parts. Treatments which reduce seedling frequency will also reduce the number of adults the following year.

The invasion of *C. rossicum* seeds from outside of the plots was likely of minor importance as a source of addition to the seedbank. According to Aldrich and Kremer (1997), dispersal falls off rapidly with distance from the source, even in wind-dispersed species. In a study of tansy ragwort [*Senecio jacobea* (L.)], which has comose seed, 60% of all seeds were found at the base of the plant, while only 1.4% were found beyond 4.6 m (Harper 1977 - in Aldrich and Kremer 1997).

Single herbicide treatments were most effective when applied in early August, when fruit maturation was well underway. However, weather, differences in plot coverage and various other factors may have influenced the efficacy of glyphosate at different treatment times. The early September treatment provided a higher degree of control than expected, since plants were largely yellowed by this point. According to Monsanto (1996), glyphosate is most effective when applied to broad-leaved perennials just before the onset of flowering, when carbohydrate reserves are at a minimum. At the time of the mid-June treatments, *C. rossicum* was at the late flower bud stage of development. In a study of herbicide control of common milkweed [*Asclepias syriaca* (L.)] Bhowmik (1982) found that glyphosate applied at 2.2 kg/ha provided 100% control after one year when applied on June 25, compared to 81% control when applied on August 30. However, studies of the effects of glyphosate on various perennial species show that there is no simple relationship between growth stage and glyphosate translocation (Franz et al 1997).

Obviously, further studies will be required to more accurately assess the sensitivity of *C. rossicum* to glyphosate at different phenological stages. This aside, it is recommended that at least one treatment be carried out before fruit maturation begins (early to mid-July in Toronto) to avoid seed set. Following treatment in early August, green fruit continued to ripen at an accelerated rate, enabling seed dispersal to occur. Although seed from these plots did not germinate, viability should not be precluded, as only a small number of seeds were tested.

It is unlikely that one year of repeated glyphosate treatments will be sufficient to control *C. rossicum* over the longer-term. After removal from competition, treated roots were able to produce new stems from living buds. This finding is consistent with other research which shows that weedy perennials can resume growth over an extended time period following glyphosate treatment. Carlson (1988) reported that two consecutive fall applications of glyphosate reduced root density of Canada thistle by 77% one year after the second treatment, but did not eradicate the roots. In another study, strong reductions in common milkweed were observed for two years following single

treatments with glyphosate, however, recovery was observed in the third year (Bhowmik 1982).

In the short-term, effective control of this species can be achieved through the reduction of seeds and perennating parts. Control over the longer-term will require the depletion of existing seed banks and the prevention of further seed production. The number of seeds in the soil, their longevity, and the number of seeds returning to the soil determines the future threat of an aggressive species (Franz et al 1997). The viability and extent of *C. rossicum* seed banks have not been studied, however, several years of treatment may be necessary to deplete seed reserves. Complete eradication must be the ultimate goal of management, since the survival of a single plant may in theory be sufficient to cause a reinfestation.

Once the presence of *C. rossicum* has been strongly diminished, another exotic species will likely replace it, unless a desired species is first introduced. In this study, sweet white clover, an alien biennial, quickly invaded herbicided plots to replace *C. rossicum* as the dominant species. Thus, control itself can create another control problem, which should be anticipated in advance of designing a treatment program (although the establishment of species such as sweet white clover may be considered desirable, since nitrogen-fixing legumes are widely used as a successional cover to enhance and protect bare soil). Careful monitoring for new invasions is important, since *C. rossicum* seedlings can persist under the dense shade of other species, making their detection difficult.

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DEVELOPMENT OF A NATIVE PLANT PRESCRIPTION FOR URBAN HYDRO RIGHTS OF WAY

Roger Suffling[1], Larry Lamb[2], Stephen Murphy[3].

1. School of Planning, University of Waterloo. 2. Faculty of Environmental Studies, University of Waterloo. 3. Department of Environmental and Resource Studies, University of Waterloo.

ABSTRACT

Ontario Hydro must save costs on mown urban rights-of-way, and its conservation policy encourages native vegetation. Thus the Corporation commissioned a study to evaluate whether a community of sown native species of prairie affinity can inhibit tall woody species. The research involves 70, 5 x 5 m plots on a gently sloping oldfield site, on Bennington series silt loam, at Kitchener, Ontario. The plots have been surveyed annually since 1996 using 7 random, permanent 1.0 x 0.5 m quadrats per plot. In Fall 1996, seed of 7 locally native species of prairie affinity was collected in the Region of Waterloo. Species were; Canada wild rye [*Elymus canadensis* L.], Indian grass [*Sorghastrum nutans* (L.) Nash], Big bluestem [*Andropogon Gerardi* Vitm.], Little bluestem [*Schizacyrium scoparium* Michx. (Nees)], Tick trefoil [*Desmodium canadense* (L.) DC.], Black-eyed Susan [*Rudbeckia hirta* L.] and Wild bergamot [*Monarda fistulosa* L.]. Sixty four plots were prepared and sown using 4 methods: 1] Fall 1996 glyphosate herbicide [1% in water applied at 380L/ha] and fall sowing, 2] Spring 1997 glyphosate and spring sowing, 3] Fall 1996 and spring 1997 rototilling and spring sowing, and 4] No preparation and fall sowing. Each preparation is managed in 4 ways: 1] Mowing, 2] Burning, 3] Mowing and burning and 4] No management. There are, additionally, 4 true controls neither sown nor managed, and 2 plots planted with plugs. Preliminary establishment results will be discussed in relation to weed competition arising from a soil seed bank that predates the last turning of the soil about 40 years ago.

Introduction

Utility companies like Ontario Hydro need to control tall woody vegetation on rights-of-way because trees cause power leakage, and because trees and tall shrubs make maintenance difficult. Control of woody vegetation is achieved conventionally through herbicides, or by mowing, and in a few instances, by brush cutting. Brush cutting has always been expensive, and mowing is also under cost scrutiny in an era of increasing economic deregulation and competition. Herbicides while effective and cheap, have proven controversial with certain elements of the public, especially in urban areas. In the light of this background, Ontario Hydro and researchers from the University of Waterloo began a study to assess the feasibility of using herbaceous species of prairie affinity on rights-of-way in urban areas. It is hoped that this vegetation offers a low-cost, environmentally benign alternative.

Tallgrass prairie has long been known to inhibit invasion of woody species (e.g. Curtis 1959). In addition, the area of tallgrass prairie has been severely reduced in Ontario (Pratt 1989), so there are conservation benefits to this approach. On the other hand, there are potential problems: Can tallgrass species be established on soils that never supported prairie in historic times? And are tallgrass communities aesthetically acceptable to the majority of the neighbouring public? A further series of questions concerns how best to establish a tallgrass system, and how to maintain it in ways acceptable to both Hydro and the public. For instance, can this vegetation be maintained without burning?

We are tackling these questions in a 3-phase program. The first phase (reported here) involves a randomised plot experiment to test establishment and maintenance techniques. The second phase will use large, semi-operational plots with the focus on costs and public acceptability, and the third phase will be a full-scale operational test. The use of progressively larger plot sizes is predicated not only on the usual process of scaling up experiments, but also on the need to generate a large seed supply without compromising wild supplies or conservation values

Methods

Experimental Site

The experimental site is Ontario Hydro's Detweiler Transformer Station on the western outskirts of Kitchener, Ontario (80°40'W, 42°20'N). The area is underlain by Bennington series silt loam and slopes gently to the East. Air photos show that the area had been under row crops in 1947, was in fallow in 1955 at the time of construction of the Hydro facility, and has subsequently developed into grassland (1967, 1971, 1975, 1980, 1985, 1990, 1995). We are informed by Hydro staff that the area has been rough-mown once or twice a year since at least 1970 and has been otherwise undisturbed. At the beginning of the experiment the vegetation was a relatively species-poor, uniform Poa/Festuca grassland.

Experimental Design

Four methods of establishment were used: Fall application of glyphosate herbicide, spring glyphosate, Fall and spring Rototilling and No preparation ("Sown Control"). Four methods of maintenance are also used, namely: Mowing, burning, mowing and burning, and no maintenance. These make 16

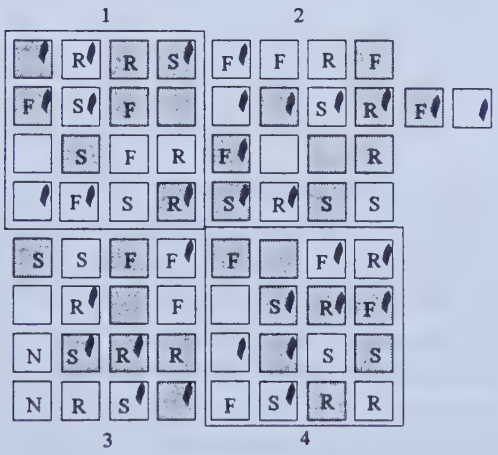


Fig. 1. The plot design. F = fall glyphosate, S = spring glyphosate, R = fall and spring rototill. No letter = sown control, N = plot unusable. Shaded = mowed, = Future burn, Numbers = replicate experiments.

combinations comprising a single experiment of 4 x 4 plots. This experimental design is replicated 4 times, making a total of 64 plots in an 8 x 8 block (Fig. 1). Each plot is 5 x 5 m within which is a 0.5-m wide buffer strip receiving treatment but in which vegetation is not sampled. No burning has been done yet, so half the plots have been mowed and the other half are unmowed. Two plots were unusable because of a soil anomaly, and these were replaced with plots adjacent to the main grid.

Procedure

In 1996 when the plots were set up, a base-line vegetation survey was conducted, seed was gathered, and selected plots were prepared and sown. In Spring 1997, the remaining plots were prepared, and sown. The vegetation survey was repeated in summer 1997 (reported here) and summer 1998. Relevant plots were mowed in the summers of 1997 and 1998, but no burn has been done yet

Plot preparation

Fall glyphosate plots were treated on 3rd October 1996 [1% Monsanto liquid Roundup in water at 380L/ha and 50 psi, using a TKSS-20 truck-mounted sprayer, with hand held hoses and #20 Flowjet Nozzles]. Spring glyphosate plots were treated on 22nd May 1997, using the same rate of herbicide application but from a backpack sprayer. The rototilled plots were mowed to 10cm height (Husqvarna 56DH highwheel rotary mower without mulching attachment), raked, and tilled on Oct 31st – Nov 6th 1996 with a 4WD Kubota tractor equipped with floatation tires, and rear-mounted FL1000 tiller. Tillage was repeated on May 22nd 1997. All remaining plots were mowed in early November 1997 to 10cm height.

Seeding of fall glyphosate and sown controls was completed on Dec 2nd 1996, just at the time of freeze-up. Spring glyphosate and Rototilled plots were sown on June 4th 1997, during a late, cold spring.

Seed Collection, Storage and Sowing

Seed was collected from several sites in North Dumfries township near Kitchener on 5 occasions in October 1996. The species were: Canada wild rye [*Elymus canadensis* L.], Indian grass *[Sorghastrum nutans* (L.) Nash], Big bluestem [*Andropogon Gerardi* Vitm.], Little *bluestem [Schizacyrium scoparium* Michx. (Nees)], Tick trefoil [*Desmodium canadense* (L.) DC.], Black-eyed Susan [*Rudbeckia hirta* L.] and Wild bergamot [*Monarda fistulosa* L.]. The seed for fall glyphosate and untreated plots was air dried, then prepared at the University of Guelph Elora Research Station. Forb seedheads were milled and winnowed, and grass heads were chopped. The grass seed was treated with Vitaflow fungicide. Forb seed was not treated because the small quantities involved would have balled up with the fungicide carrier in the machinery. The seed of each species was divided into 64 exactly equal packets for sowing. Seed for each of the 7 species was mixed immediately prior to sowing to achieve exactly the same seeding weight and species ratio for each plot. The remaining dried seed was stored at –15°C for spring sowing.

Vegetation Survey

All plots were surveyed between June and mid August 1996, 1997 and 1998 using 7 randomly placed permanent quadrats of 0.5 x 1.0m divided into 5 cells of 20 x 50cm. Each cell was rated for each higher plant and bryophyte species using a 7-class standardised dominance/abundance scale.

Soil seedbank Survey

Cores were taken from the first 25 cm soil layer of each plot (16 from the buffer area of each plot). Cores were frozen for 3 months and, following mixing with sterile soil amendments, and then placed in a growth chamber. Germination was recorded weekly for 3 months, and the seedling species identified. After 3 months the soil was frozen again for 3 months, and then observed, as before for 3 months. This procedure allows one to measure the species present and their relative numbers. The first samples were collected in September 1996, and the experimental run was completed in September 1997. A further series of samples is currently under observation.

Results and Discussion

Establishment of Sown Species

Abundance data for the 7 sown species were collated by treatment. Many cells within quadrats, and many whole quadrats within plots, did not contain germinated seedlings of the sown species in summer 1997 (or perhaps the seedlings were too small to be identified at that time). This made the intended complex analysis of variance (ANOVA) untenable because assumptions of statistical normality inherent in ANOVA would be violated. The data were therefore blocked into 4 replicates x 4 treatments x 28 observations. Complete absence of germination in sown controls and/or spring glyphosate treatments in *Rudbekia, Sorghastrum and Andropogon* compromised the sensitivity of Least Significant Difference (LSD) tests. These species' data were therefore re-analysed without sown controls, and these LSD results are reported in Figure 2.

Laboratory tests showed that germinability of *Schizacyrium scoparium* was very low, and this was reflected in complete absence in the vegetation samples. *Elymus canadensis* was also absent from the samples, though it had germinated at low rates in the laboratory. The remaining five species all germinated in numbers, and only these are discussed hereafter.

All five species had significant differences between treatments (ANOVA F-test, $P<0.05$). The sown controls had negligible numbers of *Andropogon gerardi* and *Rudbekia hirta* (Fig. 2). As expected, establishment of the other three species was also very sparse on control plots. The fall glyphosate treatment was effective in establishing 4 of the 5 species, but *Desmodium canadensis* had all but failed to show at the date of the 1997 survey. Spring glyphosate was most effective in promoting the establishment of *Andropogon gerardi*, and there was a little *Monarda fistulosa* and *Desmodium canadense*. *Sorghastrum nutans* and *Rudbekia* failed under this regime. The rototill treatment was effective for *Desmodium*, slightly effective with *Monarda*, *Andropogon* and *Rudbekia*, and failed with *Sorghastrum*.

Soil seedbank Observations

The main species in the seed bank (Table 1) were *Medicago lupulina* (black medick), *Ambrosia artemiisifolia* (common ragweed), *Sonchus oleraceus*, *Agrostis tenuis* (Rhode island bent/trembling redtop), *Prunella vulgaris* (selfheal), *Amaranthus retroflexus* (redroot pigweed), *Elytria repens* (quackgrass), *and Phleum pratense* (timothy grass). Only one native species *(Panicum capillare* witchgrass/ panic grass) was represented by more than 50 germinating seeds. Two natives in the seed bank, *Conyza canadensis* (horseweed) and *Echinocystis lobata* (wild cucumber), are appropriate to

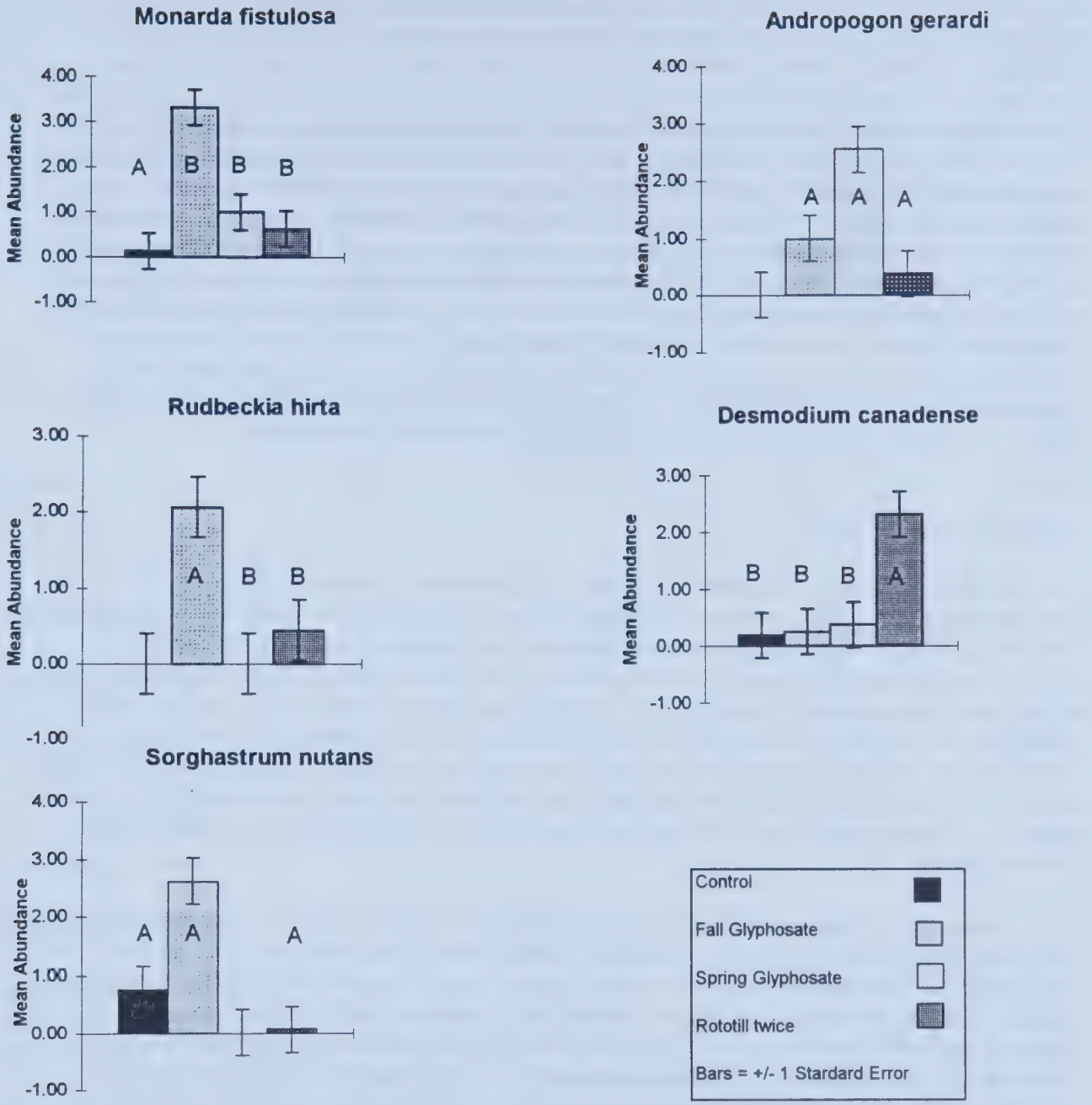


Fig. 2. Seedlings observed during the first growing season. Scores are on a 7-point cover-abundance scale. Bars are +/- 1 Standard error. Letters indicate classes not differing significantly ($p<0.05$) in LSD tests.

tallgrass prairie but are potentially invasive in areas bordering rights-of-way, and this may prove a problem. The early dominance of *Medicago lupulina* on rototilled plots in 1997, while not reported in the present data, was especially striking.

Forty-six species, mainly weeds that germinated from the seed bank had not been observed in the ambient plant survey in 1996. Thus they probably did not invade as seeds from surrounding habitat but have the potential to reinvade from the long-lived seed bank. Of particular interest are *Alliaria petiolata* (garlic mustard), *Cerastium vulgatum* (mouse-eared chickweed), *Medicago lupulina* (black medick), *Setaria pumila* (yellow foxtail), *Setaria viridis* (green foxtail), *Sonchus arvensis* (perennial sow thistle) and *Sonchus oleraceus* (annual sow thistle) which are highly invasive. *Setaria pumila* was not observed in either the ambient or the systematic surveys, but it is likely that this species had been grouped with *Setaria viridis* as they are difficult to distinguish. Two other species, *Elytria repens* (quackgrass) and *Taraxacum officinale* (common dandelion) did not germinate from seeds, but rhizomes and roots re-sprouted. All of these weeds need to be controlled by whatever rehabilitation technique is used, or they are likely to overrun the site, once released from dormancy.

Discussion and Conclusions

As evidenced by low germination rates on controls, site preparation is necessary for effective establishment of these prairie species. The aggregate best "take" of seed for all species can be achieved with Fall glyphosate application, but double rototilling is effective as an alternative to promote *Desmodium*. One should be aware, however, that this result only applies to initial establishment: Some of the species have appeared in quantity in 1998 where they initially failed in 1997, but these results are not collated at the time of writing (July 1998). In particular, we note numbers *of Elymus canadensis* establishing on the glyphosate plots during 1998. It is possible that the very similar seedlings of *Elytria* and *Elymus* were confused in the 1997 survey. Also, the results only apply to the weather in the year of the test - It is quite possible that other patterns of temperature and precipitation would have yielded different results.

On the basis of the above, an effective strategy to establish the widest variety of species would be to apply glyphosate in Fall, sowing a mix of species (minus *Desmodium*) soon after. Then patches of the area should be rototilled in spring and sown to a mix containing *Desmodium* and lacking *Sorghastrum*. If it is important to establish *Andropogon* (and this might be true for both ecological and aesthetic reasons), then further patches can be glyphosate treated in spring and sown to *Andropogon* and *Monarda*. The first approach will be most cost effective, with the second and third adding further species to the community, but with greater cost and effort. The second and third approaches could therefore be concentrated on prominent areas, such as near highways or the entrances to recreational trails along a right of way.

The short and long-term effectiveness of any ecological rehabilitation strategy can be measured in changes in the population of viable seeds in the soil. There should be a decline in the numbers of seeds of nuisance species (e.g. *Cirsium, Medicago*), and a corresponding diminution in numbers of mature plants. Seeds of some weed species can be long lived as evidenced by large numbers of viable *Medicago lupulina* and other seeds. *Medicago*, in fact, appeared in large numbers on the rototilled plots in both 1997 and 1998. Thus the preparation for seeding, though necessary, should not include a general cultivation, regardless of how long the site has remained uncultivated. Glyphosate has an

Table 1. Seed germination from September 1996 (pre-management) soil samples at Detweiler.

The second column indicates how many samples (out of a total of 1056) had germinating seeds of a given species. The third column indicates how many plots (out of a total of 66) had germinating seeds from a given species. For the last two columns, 0 and 1 indicate absence and presence respectively of a species. Nomenclature follows Morton and Venn (1992). Taxonomic synonyms include: *Alliaria petiolata* (= *A. officinalis*), *Agrostis capillaris* (= *A. tenuis*), *Aster lateriflorus* (= *A. vimineus*), *Cerastium fontanum* (= *C. vulgatum*), *Conyza canadensis* (= *Erigeron canadensis*), *Elytrigia repens* (= *Agropyron repens* = *Elymus repens*), *Epilobium ciliatum* (= *E. glandulosum*), *Euthamia graminifolia* (= *Solidago graminifolia*), *Festuca arundinacea* and *Festuca pratensis* (both = *F. elatior*), *Setaria pumila* (= *S. glauca*), *Oxalis stricta* (= *O. europea*). * = native to Canada.

Species	# seeds germinated	# samples from which seeds germinated	# plots from which seeds germinated	Ambient survey	System surve
Achillea millefolium	5	3	2	1	1
Agrostis capillare	87	71	64	1	1
Agrostis stolonifera	3	1	1	0	0
Alliaria petiolata	11	4	2	0	0
Alopecurus pratensis	2	1	1	1	0
Amaranthus powellii	13	7	4	1	0
Amaranthus retroflexus	79	68	61	1	0
Ambrosia artemisiifolia	116	81	62	1	0
Arctium minus	1	1	1	1	0
Asclepias syriaca*	14	8	8	1	1
Aster lateriflorus*	0	0	0	1	0
Aster novae-angliae*	9	7	4	1	1
Bromus inermis	27	18	15	1	1
Cerastium fontanum	61	42	26	1	1
Cirsium arvense	10	7	4	1	1

Cirsium vulgare	18	16	12	1
Chenopodium album	46	37	31	1
Chenopodium botrys	0	0	0	1
Conyza canadensis*	5	3	2	1
Cornus stolonifera*	0	0	0	1
Cyperus esculentus*	0	0	0	1
Dactylis glomerata	19	14	12	1
Daucus carota	3	1	1	1
Dipsacus fullonum	0	0	0	1
Echinochloa crus-galli	0	0	0	1
Echinocystis lobata*	0	0	0	1
Echium vulgare	3	1	1	0
Elytrigia repens	79	56	47	1
Epilobium ciliatum*	0	0	0	1
Epilobium parviflorum	2	1	1	0
Equisetum arvense*	0	0	0	1
Eragrostis pilosa*	7	3	2	0
Erigeron annuus*	4	2	2	1
Erigeron philadelphicus*	1	1	1	1
Erysimum cheiranthoides	6	3	3	1
Euphorbia cyparissias	1	1	1	0
Euthamia graminifolia*	0	0	0	1
Festuca arundinacea	22	17	15	1
Festuca pratensis	29	24	21	1

Fragaria virginiana*	18	11	10	1	1
Galium mollugo	6	4	2	0	0
Hieracium aurantiacum	7	2	2	0	0
Hieracium caespitosum	27	23	22	0	0
Hieracium floribundum	2	2	2	0	0
Hordeum jubatum	1	1	1	1	0
Hypericum perforatum	9	6	5	1	1
Lactuca serriola	2	2	2	0	0
Leersia oryzoides*	0	0	0	2	0
Leonurus cardiaca	0	0	0	0	0
Linaria vulgaris	0	0	0	1	0
Malva neglecta	0	0	0	1	0
Matricaria matricarioides	0	0	0	1	0
Medicago lupulina	188	143	54	1	1
Melilotus alba	0	0	0	1	0
Melilotus officinalis	0	0	0	1	0
Oenothera biennis*	0	0	0	1	0
Oxalis stricta*	47	31	30	1	0
Panicum capillare*	52	44	41	1	0
Panicum flexile*	13	11	7	1	0
Parthenocissus quinqufolia*	4	4	4	0	0
Phleum pratense	73	52	40	1	1
Plantago major	0	0	0	1	0
Poa compressa*	32	15	9	1	1

Poa nemoralis	11	6	5	0
Poa pratensis*	65	48	42	1
Poa trivialis	7	4	1	0
Polygonum aviculare	4	3	3	1
Polygonum convolvulus	16	13	12	0
Prunella vulgaris	84	61	25	1
Prunus sp. (possibly *)	0	0	0	0
Rhamnus cathartica	5	4	4	1
Rhus typhina*	2	1	1	0
Rubus idaeus (possibly *)	0	0	0	1
Rumex crispus*	0	0	0	1
Scirpus atrovirens*	0	0	0	1
Solanum dulcamara	0	0	0	1
Setaria pumila	42	29	22	0
Setaria viridis	57	38	31	0
Silene noctiflora	5	3	2	0
Solidago altissima*	1	1	1	0
Solidago canadensis*	6	4	4	1
Solidago rugosa*	0	0	0	1
Sonchus arvensis	77	68	50	0
Sonchus oleraceus	92	84	79	0
Sorghastrum nutans*	3	1	1	0
Sporobolus vaginiflorus*	14	9	4	1
Stachys palustris	1	1	1	0
Stellaria media	18	12	8	0

Tanacetum vulgare	0	0	0	1	0
Taraxacum officinale	55	40	32	1	1
Thlaspi arvense	34	32	27	0	0
Tragopogon pratensis	6	5	5	0	0
Trifolium hybridum	19	8	7	1	1
Trifolium pratense	24	16	11	1	1
Trifolium repens	14	10	10	1	0
Tussilago farfara	0	0	0	1	0
Typha latifolia*	0	0	0	1	0
Verbascum thapsus	23	17	14	1	0
Veronica arvensis	5	3	1	0	0
Veronica officinalis	11	8	6	0	0
Veronica serpyllifolia*	4	2	1	1	1
Viola kitaibeliana	31	18	13	0	0
TOTAL	1897				

obvious advantage over rototilling in that it does not expose buried seeds of nuisance species. On the other hand, limited soil disturbance is necessary to encourage *Desmodium* and similar species. Cultivation of specific areas to establish species needing mechanical disturbance can be regarded as a trade off between incurring weed problems and maximising biodiversity.

The baseline seedbank observations proved useful in showing the huge numbers of viable weed seeds that remain after 40 years without soil disturbance. In the next few years we shall be tracking the relative numbers of viable weed and native species to see if the relative success of various management regimes is predicated on soil seedbank populations.

Acknowledgement

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A System for Urban Wildlife Habitat Restoration

Marshall Buchanan, M.Sc.F., R.P.F.

Neighbourhood Environmental Science & Technology (NEST)

ABSTRACT

NEST is an environmental consulting firm which specializes in community oriented forest science. Clients include non-profit environmental groups such as Grassroots Albany, the Association for Community Educational Resources (ACER), Thomas Simpson Secondary School, N.W.T, Gwich'in Renewable Resources Board, Inuvik, N.W.T. and the Eastern Ontario Model Forest. Typical government clients include the Rouge Park, Environment Canada, the Regional Municipailty of York and the Ontario Forest Research Institiute. NEST also devotes considerable effort to provide forestry expertise to owners of small privately owned forests (10 acres) to large private resorts such as the Domain of Killien (5,000 acres). Conservation is the cornerstone of our philosophy. NEST is an active member of Canada's Environmental Monitoring and Assessment Network (EMAN).

The lack of habitat structure in urban greenspaces landscapes severely limits opportunities for wildlife to successfully forage, breed, and seek shelter. Recent research suggests that landscape structure may be more important to wildlife than the presence of a particular species of plant. NEST has therefore attempted to create a holistic approach to urban restoration by combining revegetation with habitat structures such as coarse woody debris, snake hibernacula, cavity snags, and raptor roosts. Together these habitat components provide an immediate network of sheltering and feeding opportunities for wildlife at both lower and upper positions in the food web. Functional habitat is created in this holistic approach to restoration because landscape structure is integrated with revegetation. From an educational point of view, this system provides and excellent model for teaching students about forest dynamics and the importance of decomposition to forest renewal and the cycle of life.

Introduction

After working on community reforestation projects for 10 years in the Rouge Park, NEST has developed a system for improving the immediate and long-term benefits of community restoration projects to wildlife. This holistic approach combines community based revegetation with a set of landscape structures to provide habitat for a hierarchy of wild fauna. The intent is to restore habitat features which support wildlife at different trophic levels to create functional, effective and self-sustaining wildlife habitat. This approach has been applied to 3 different locations in the Rouge Park , most recently in an abandonned farm field 500 metres south of Steeles Avenue on the east side of Sewells Road in Scarborough.

Habitat Features

Vegetation

The re-vegetation strategy followed the "nucleation" technique. Circular patches (20 - 25 metres in diameter) were plowed and then tilled with a tractor mounted rotary tiller. Pioneer species such as poplar were planted at high densities within these patches. The roto-tilling greatly improved the quality of the planting job performed by volunteers. Plowing without tilling usually leaves furrows which can flood and drown seedlings. On tilled

patches, the planters dug large holes with relative ease and they packed the loosened soil around seedling roots without leaving the air spaces that cause root desiccation. Roto-tilling also improved short-term weed control and provided a level surface for the placement of cardboard brush mats. Approximately 150 bales of straw were spread over the brush mats and exposed mineral soil to enhance weed control and reduce moisture stress. Native wildflowers were hand seeded directly to roto-tilled soil in designated meadow areas such as the hydro and oil pipeline right-of-way.

Cavity Snags

Snags (standing dead trees) were installed at the center of selected nuclei (see map next page). The intensive reforestation of these patches will quickly shelter the snag and enhance the habitat it provides. They provide vertical structure to the landscape and provide nesting and foraging structures for birds. Two or three cavities (2" in diameter) were excavated in the snags at different orientations and heights to provide nesting and foraging opportunities for birds such as tree swallows, wrens, bluebirds, shrikes, red-headed woodpeckers, flickers, etc. So far tree swallows and wrens are the most frequent nesters in the cavity snags although bluebirds and flickers have been observed "investigating" the cavities.

As the planted seedlings grow around the snags, interior forest habitat will be created which will provide opportunities for different birds and small mammals such as flying squirrels. The snags also provide unique visual appeal. The sight of fourteen snags standing in the regenerating area helps one imagine the forest that previously dominated the landscape.

Coarse Woody Debris

Approximately 40,000 pounds of culled hardwood logs from Tembec Inc. (Huntsville Division) were used as a source of coarse woody debris for this project. Fallen trees and decaying logs play an important role in forest ecosystems. Within the food web, they represent both the end and the beginning. Decaying logs enrich the soil while providing food for many organisms near the bottom of the food web. Organisms such as fungi, invertebrates, arthropods and insects occupy this trophic level. At the same time, deadwood provides nesting and foraging areas for amphibians and small mammals such as weasels, mice and meadow voles. The coarse woody debris was positioned to create travel corridors between planted patches and to create small log piles suitable for shelter, mating displays, and feeding. Eastern bluebirds were observed foraging for insects on the ground and then crushing the exoskeletons of their prey on the hard surfaces of downed logs.

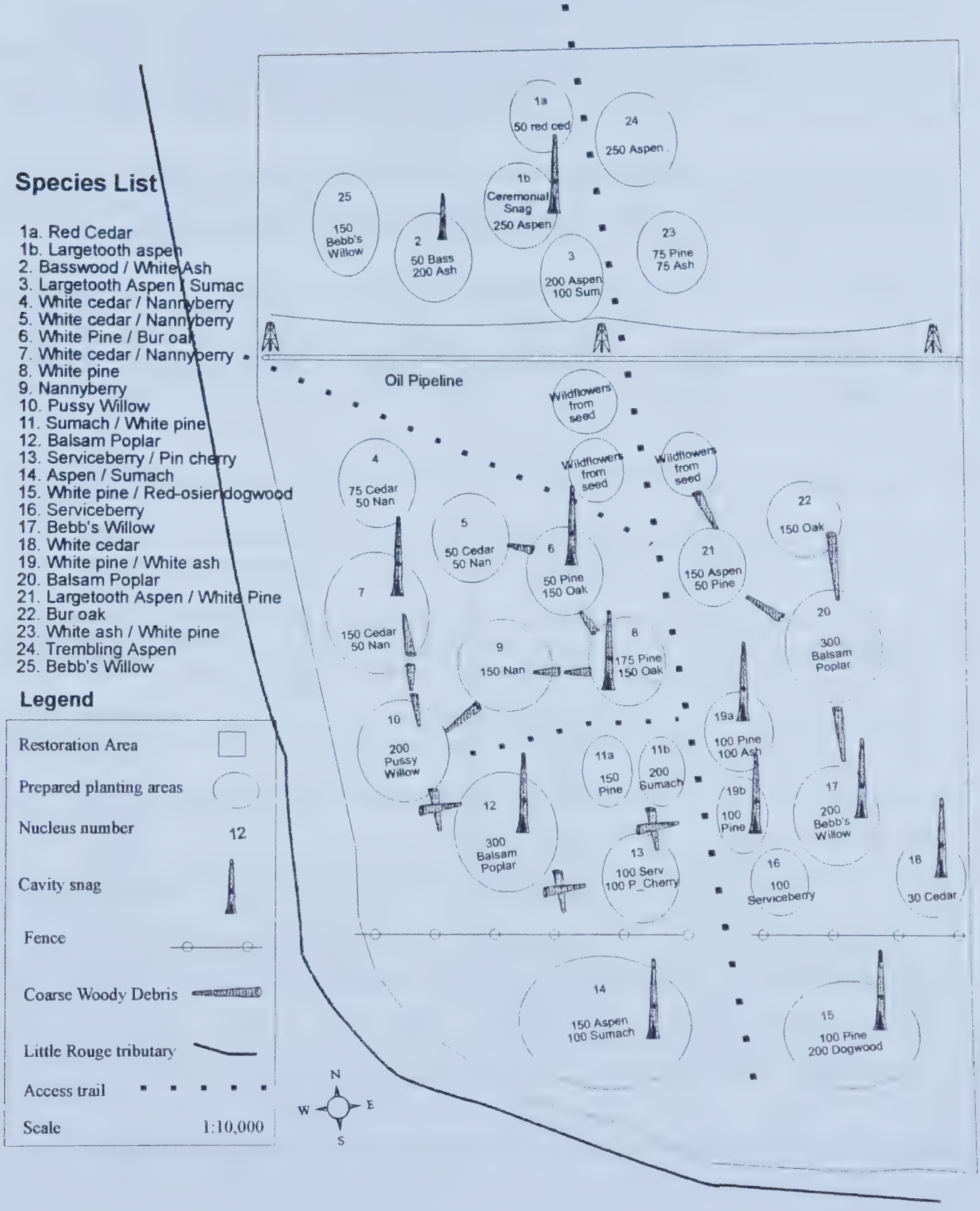
Snake Hibernaculum

Snakes are probably the most important reptiles in old field ecosystems. During the summer, these ground level predators will directly benefit from the habitat and food generated by the coarse woody debris. During the winter however, snakes are in danger of dehydrating and/or freezing. As a result, a snake hibernaculum was built on the site. The structure is a stone and wood complex which allows snakes to overwinter underground in a moist environment protected from freezing temperatures. The temperature and moisture level within the hibernaculum can be monitored through a plastic tube installed in the structure.

Raptor Nesting Snag

One 22 foot snag suitable for nesting raptors (i.e. buteos, accipiters, harriers, ospreys) was also erected on the site. Passerines have also been seen roosting on this snag during hot afternoons. They perch facing into the wind, perhaps trying to stay cool.

Planting and Habitat Structure Plan



Education/Research/Monitoring

Long term monitoring of wildlife activity on the site will generate feedback concerning the success of this initiative. Birds are a popular group of species and many volunteers enjoy watching and recording their movements on restoration areas. The variety of birds observed during preliminary surveys of this site are listed in Table 1 below. Pitfall traps have been installed on the site to sample populations of ground fauna. Due to the the addition of the coarse woody debris and the concentration of tree planting in circular patches, we expect to detect differences in the diversity and abundance of arthropods on the site.

By combining the installation of these habitat features with the 10,000 Trees for the Rouge planting event, approximately 1,000 members of the general public learned about some of the specific characteristics of a forest that are essential to the survival of salamanders, snakes, frogs, woodpeckers, songbirds and raptors.

Order	Family	Common Name	Order	Family	Common Name
Ciconiiformes	Ardeidae *(Herons)*	Great blue heron	Passeriformes (continued)	Mimidae *(Mimic thrushes)*	Gray catbird
Anseriformes	Anatidae *(Waterfowl)*	Canada goose		Turdidae *(Thrushes)*	Robin
		Mallard duck			Eastern bluebird
Falconiformes	Cathartidae *(Vultures)*	Turkey vulture		Bombycillidae *(Waxwings)*	Cedar waxwing
	Buteoninae *(Buteos)*	Red-tailed hawk		Sturnidae *(Starlings)*	European Starling
Columbiformes	Columbidae *(Pigeons, Doves)*	Mourning dove		Parulidae *(Wood warblers)*	Common Yellowthroat
Piciformes	Picidae *(Woodpeckers)*	Common flicker		Icteridae *(Blackbirds)*	Bobolink
		Downy woodpecker			Eastern Meadowlark
Passeriformes	Tyrannidae *(Flycatchers)*	Eastern kingbird			Red-winged blackbird
		Alder flycatcher			Baltimore oriole
	Hirundinidae *(Swallows)*	Tree swallow			Common grackle
	Corvidae *(Jays, Crows)*	Blue jay			Brown-headed cowbird
		American Crow		Fringillidae *(Finches)*	American goldfinch
	Paridae *(Titmice)*	Black-capped Chickadee			Savannah sparrow
	Troglodytidae *(Wrens)*	House wren			Song sparrow

Table 1. Partial list of birds observed on the restoration site during preliminary monitoring surveys.

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LONG TERM MONITORING OF A WETLAND ECOTONE IN SOUTHERN ONTARIO, IMPLICATIONS FOR ENVIRONMENTAL PLANNING

Robin van de Lande and Paul F.J. Eagles Ph.D.

University of Waterloo

ABSTRACT

A long-term study of vegetation and groundwater in a wetland ecotone yielded data relevant to the field of environmental planning. During a five year period, the vegetation in 16,400 m^2 monitoring plots was monitored across a 60 ha wetland. Results of vegetation monitoring were linked with seasonal groundwater levels as well as precipitation and canopy characteristics. Regression analysis of the accumulated data showed that seasonal groundwater levels greatly influence vegetation habitats in the ecotone. Specifically, groundwater levels in the fall of the previous year had the greatest influence on vegetation habitats measured during the next growing season. The study also demonstrated that the fecundity of individual plant species were not linked with groundwater levels. In fact, only one species of 90 was correlated with groundwater levels.

From a design perspective, this study shows that seasonal water inundation impacts wetland plant community species composition. It is important to note that the study shows that the community is impacted by water level fluctuations however, impacts at the species level are difficult to predict. Restoration plans therefore need to integrate a wide variety of plant species, both upland and wetland. The study identifies a yearly low groundwater level of approximately one metre below the surface as the boundary between wetland and dryland.

THE MOUNT FOREST WETLAND SANCTUARY PROJECT

Don Smith

Saugeen Valley Conservation Authority
Hanover, Ontario

Art Bos, P. Eng

Bos Engineering and Environmental Services
London, Ontario

Dave Hayman

D. G. Hayman Environmental Consultants
London, Ontario

ABSTRACT

The South Saugeen River, in the Town of Mount Forest, Ontario, contains a 10 hectare reservoir created by a dam originally constructed in 1856, and most recently rebuilt in 1983.

Accumulated sediments in the reservoir have contributed to an unstable reservoir bed, exposed mud flats during periods of low flow, and a dynamic flow pattern within the reservoir. These conditions have encouraged undesirable species of aquatic vegetation to thrive and have also attracted a large Canada geese population. The public has demanded that the reservoir be rehabilitated.

Work has commenced on a project that will create a four hectare wetland by constructing a stone barrier/flow deflector across a portion of the reservoir and concentrating the flow of the river to its original channel. Facilitated by minor manipulations of water levels through dam operations, sediments will accumulate upstream of the in-reservoir barrier. In the spring of 1999, water levels will be lowered to the final depth. Native wetland vegetation will be introduced to the newly created wetland area. Public trails and viewing areas will be constructed adjacent to the wetland. Project construction started in June of 1998 and is scheduled to be completed by the fall of 1999.

This grassroots community/municipal project is being guided by a local steering committee, has been designed by private consultants, and is being co-ordinated by the local Conservation Authority. Implementation will be assisted by schools and volunteer groups. Local donations, combined with those from foundations, corporations, and government agencies, will cover all construction costs.

Introduction

The Town of Mount Forest is situated at the junction of Highways 6 and 89, at the northern extent of Wellington County, Ontario, approximately 65 km north of the City of Guelph. It has an approximate population of 4,200 people.

which flows in a westerly direction traversing the southern portion of the municipality. A dam, situated at the Highway # 6 bridge, forms a 10 hectare reservoir, or mill pond as it is referred to locally. The upstream drainage area for this reservoir is 235 square kilometres.

In the past local residents have been proud of the reservoir which dominates the southern portion of the Town, not only for its aesthetic value, part of which is the impressive view that it offers for anyone travelling on Highways # 6 or 89, but also for the recreational opportunities that it provided such as boating, swimming and hiking. In recent years this pride has changed to disappointment with the public perception that the quality of the reservoir was quickly deteriorating. The public was observing shallow water depths, areas of stagnant water, excessive weed growth, and declining recreational use. In general, the public was not pleased with the unsightly appearance of the reservoir and voiced this concern to municipal officials and staff of the Saugeen Valley Conservation Authority (SVCA).

Discussions between the Town and the Conservation Authority, concerning the condition of the reservoir, have been ongoing for several years. These discussions became more intense in 1993 and 1994 as public concern increased. The result was an extensive rehabilitation study as well as subsequent design work, planning and fundraising. At this time the community of Mount Forest is in the process of converting a reservoir of deteriorating quality into a biologically diverse wetland environment through the implementation of The Mount Forest Wetland Sanctuary Project.

The Problem

Extensive accumulations of sediment in the reservoir have created shallow water levels and a reservoir bed that is in an unstable condition. This has brought about outbreaks of aquatic vegetation and dynamic flow patterns which in turn have uprooted vegetation in some locations. Large populations of waterfowl, particularly Canada Geese, have been attracted to the reservoir with a resultant increase in bacterial populations and unhealthy conditions for recreational activities.

Factors Contributing to The Problem

The very existence of the Town of Mount Forest is due in part to the source of water power provided by the South Saugeen River for milling operations. A dam was first constructed immediately upstream of the Garrafraxa Road (Highway #6) bridge in 1856 (Edwards 1979), and although it has been rebuilt or modified a number of times, it has acted as at least a partial barrier to the natural flow of sediments for over 140 years. The dam underwent a major reconstruction in 1983 to repair leakage problems. This reconstruction work may have improved the ability of the dam to trap sediments. Sediment levels in the reservoir have reached a state of equilibrium with the reservoir acting as a sediment trap during periods of low flow and a sediment source during periods of high flow (Bos and Hayman 1996).

The practice of removing the stop logs from the dam each fall, which would lower the water levels by .45 m, and replacing them each spring, was discontinued in the late 1980's with the logs being removed permanently. Reconstruction and the termination of dam operations have created a shift in the depositional and flow areas within the reservoir (Bos and Hayman1996). In addition, permanently lowered water levels have increased the amount of exposed mud flats, accelerated the warming of the water, and contributed to the proliferation of certain species of aquatic vegetation (Bos and Hayman 1996).

The factors described above have created an environment where plant communities tend to be discontinuous and not well established which is likely due to the extensive sediment movement within the reservoir during high flow conditions (Bos and Hayman 1996).

It has been estimated by Campo (1994) that approximately two thirds of the sediment reaching the reservoir originates from specific streambank erosion sites on high glacial banks of the South Saugeen River upstream of the reservoir. Only 25% of the watershed is farmed at high intensity (Ecologistics 1990) which would suggest that sediment originating from non-point sources would be relatively low. Snell (1984) estimates that total sediment loads for the entire area would be categorized as low priority for soil conservation practices.

Reservoir Rehabilitation Alternatives

Numerous alternatives were reviewed with input from the local Steering Committee. However, as the analysis proceeded, it became clear that few of the alternatives were stand-alone single solutions and that the ultimate solution would likely require implementation of a combination of the alternatives.

The alternatives considered were:

- Do Nothing
- Increase Water Velocity
- Deepen Reservoir
- Upstream Improvements

1. Do Nothing

The option of ignoring the problem was attractive only from the standpoint of cost. However, the community would not accept the deterioration of the reservoir that represented a major landmark for the Town. The reservoir had previously provided recreational opportunities that had since been lost due to the siltation problem. The community would not accept the "Do Nothing" alternative.

2. Increase Water Velocity

Increased water velocity in the reservoir reduces the rate of sediment deposition and thereby provides a longer-term solution to the problem of continued degradation. Several methods were considered to achieve this:

a) Lower Water Levels

Lowering the water levels in the reservoir could be achieved by complete removal of the dam or by reducing the elevation of the weir outlets of the dam. Complete removal of the dam would eventually return the river back to its original state. However, the structural implications on two local bridges, and the cost of the demolition itself, made this option prohibitive. Partial lowering of the weir elevations was also prohibitive, as the minimum water levels were required to provide frost protection for the dam seal. The least expensive means to lower the water levels by approximately .45 m was the permanent removal of the existing stop logs in the dam. On the positive side, this would expose land around the reservoir for wetland, education and land-based uses and would reduce the required area for possible dredging. On the negative side, this would reduce the reservoir size and cause potential further warming of the shallow waters leading to, perhaps undesirable, aquatic vegetation.

b) Install In-Reservoir Barriers / Flow Deflectors

Strategic installation of barriers within the reservoir would deflect flow and selectively stabilize bottom sediments where desired. Hence, desirable wetland plant communities can be established and maintained. Velocities would reach higher levels in the areas that are not barricaded which would reduce further siltation. This alternative enhances the ability of the reservoir to self-rehabilitate. However, there is some capital cost associated with this alternative.

c) Bottom Draw

The dam is equipped with a bottom draw pipe and valve that was installed for the purpose of emptying the reservoir for maintenance. Use of this pipe as a permanent outlet was considered to allow the flow-through of sediments during low flow periods and to provide aeration of the less oxygenated deeper waters. However, the pipe and valve were not designed for permanent use and the current depth of sediment around the intake made this alternative more costly than originally thought. In addition, a new flow control system would be required to ensure that the reservoir did not inadvertently empty and to protect against blockages.

3. Deepen Reservoir

An increase in reservoir depth would reduce the negative impacts of the siltation problem by cooling the water. This could be accomplished either by dredging or by raising water levels by raising the weir outlet.

a) Dredging (full or partial)

It was determined that dredging would provide immediate benefits to the reservoir. However, there were two major drawbacks. The cost of dredging the complete reservoir would be extremely high. And if the current silt loads were to continue without other preventative actions, the community would eventually face the same dilemma. Partial dredging in association with other measures could be more feasible.

b) Raise Water Levels (Increase Stage)

The existing dam can accommodate installation of stop logs to inexpensively raise water levels by approximately .45 m. A permanent increase in the stage provides a good short-term solution, although eventually the silt levels would build to the new elevation leaving a similar problem. In addition, the permanent increase in stage would affect the flood lines around the reservoir. Insertion and removal of the stop logs to reduce the flood impact would be an on-going maintenance concern with safety problems, and such operation would continue the instability of the reservoir bottom.

4. Upstream Improvements / Measures

Regardless of the in-reservoir solutions, control of upstream silt load sources would of course assist in any solution. There is however, a general acknowledgement that this is a long term educational solution due to the ownership of the upstream source lands by many individuals. Upstream sources can be addressed by:

- Streambank erosion control
- Agricultural erosion control
- Upstream sediment basins
- Protection of upstream wetlands

The South Saugeen River has several sites where large landslides have historically occurred. Control of such sites could reduce the silt loads to the reservoir by as much as 70%. However, these sites would have substantial costs associated with remediation.

Agricultural sources are not prevalent in this watershed and hence remediation of these few sources would not alone have a significant impact. However, ongoing development and drainage of the large upstream wetland complex will increase this potential source and will reduce the ability of the reservoir to attenuate flash floods. The continued development of wetlands, in turn, will increase the potential risk of bank erosion problems.

The reduction of silt loads without complete elimination would not reduce the ability of the reservoir to trap sediments. Most of the above sources are based on private lands and hence are out of the direct control of the

municipality and the Conservation Authority.

Hence, the control of upstream sources is really a longer-term educational solution without guarantees. Installation of upstream sediment basin(s) was found to be uneconomical and not cost-effective.

Phased Plan

There was a financial need to phase the rehabilitation plan. The logical order of implementation together with the availability of financial resources were the primary considerations. The actions were divided into three time frames for implementation.

1. Immediate Implementation

a) Reinstallation of Stop Logs
Stop logs were to be reinstalled in the existing small weirs of the dam. This would provide short-term relief to the current unsightly mud flats that were previously exposed during the summer months. Although this would not represent a significant improvement to the overall environmental health and dynamic problems of the reservoir, it does provide immediate aesthetic results.

b) Design of In-Reservoir Barriers / Flow Deflectors
Detailed design and cost estimate were to be developed for the barriers/deflectors to be strategically located within the reservoir to concentrate flow velocities in defined areas. The barriers would enhance sedimentation and prevent scouring of the shallow areas slated to become a future marsh/wetland.

c) Planting Plan
A planting plan would be developed for desirable wetland species and trees.

d) Fund Raising
Necessary funding for the capital costs associated with the construction aspect of the project would be raised from a variety of sources.

e) Upstream Wetland Preservation
The Saugeen Valley Conservation Authority, and the municipalities upstream of the Mount Forest Reservoir, would continue to implement planning controls to preserve the significant areas of upstream wetlands which buffer sediments and pollutants and which serve to maintain summer water flows to the reservoir.

2. Medium-Term Implementation (one to three year time-frame)

a) Installation of In-Reservoir Barriers / Flow Deflectors
With funds available, the barriers/deflectors would be installed to enhance sedimentation in desired areas and to scour the proposed main flow paths through the basin during high flows.

b) Manipulation of Stop Logs for Wetland Deposition
After the installation of the barriers/deflectors, the reservoir stage would be raised by installing the stop logs which would be left in place for several consecutive significant runoff events to build up the proposed wetland area with additional sediment deposits. Subsequently, the boards would be permanently removed to facilitate the proliferation of desirable plant species which will be introduced into the reservoir.

c) Wetland Vegetation Establishment

Upon completion of the barriers/deflectors, appropriate wetland vegetation will be planted in the sediment deposits in accordance with the planting plan. This will be done from a shallow pontoon while water levels are temporarily raised.

d) Other Enhancements
Once the preceding tasks are completed, it will be possible to install various enhancements to encourage community use of the reservoir such as trails, boardwalks, and interpretive signage for educational purposes. The placement of nesting boxes and platforms to attract desirable birds for nesting and/or staging during migration will also be undertaken.

3. Longer-Term Implementation (more than five year time-frame)

a) Partial Dredging
After completion of the medium time-frame tasks, selective dredging may be required to better define and concentrate flows through the reservoir. This dredging would remove mainly the coarse deposits which were not scoured during high runoff events. The objective would not be to significantly deepen the channel.

Creating Wetland Conditions - Progress to Date

Wetland conditions were to be created by reducing the effective reservoir size and by the construction of an in-reservoir barriers/deflectors to stabilize the bottom sediments in selected areas.

a)Design and Implementation of In Reservoir Barrier / Flow Deflector
Flow deflection, using submerged barriers were recommended by Bos and Hayman (1996) to enhance sedimentation in selected areas and to confine the reservoir flow to a specific route. This will create a more stable reservoir bed with defined depositional areas and a concentrated flow path with higher velocities. The stable depositional areas will have increased ability to support vegetation to maturity.

The design result was a single barrier/deflector system positioned to restore the natural south meander channel of the original river. The barrier/deflector was constructed in June of 1998. The barrier has not completely closed the north channel during high flow periods providing some relief for the south flow channel. This will facilitate sedimentation in the north channel and will reduce potential bank erosion impacts at the south shore of the reservoir. The increase in velocity of the south channel flow will cause some scouring of the south channel bottom, which is desired. The barrier placement also capitalizes on the existing sediment deposits and provides an opportunity for enhancement of a natural wetland formation.

A series of probings were carried out to determine the elevations of both consolidated and unconsolidated sediments. The probings were carried out along several radii in the vicinity of the proposed wetland and bottom contours were developed from the data. These contours were used in positioning the barrier and for estimating material and labour quantities. The most economical route was selected based on minimizing the depth along the path of the barrier. This, in turn, minimized the quantity of imported construction materials.

The most economical barrier/deflector construction was determined to be rock rip-rap. Initially, it was intended to excavate to consolidated sediments for an adequate base. However, it was determined that use of "Tensar Biaxial Geogrid™ " (or equivalent) on a geotextile blanket would eliminate the need for such excavation. This provided a significant cost advantage and greatly reduced potential environmental concerns due to construction. This material works by providing a flexible planar base that distributes the weight of the imported materials uniformly over the sediment. Although some initial settling did occur, this was expected to be relatively uniform and was allowed for in the design. Minor settling variations were accommodated by the flexibility of the rip-rap to conform. The two

major advantages of using a system where rip rap materials float on the existing sediment deposits were cost savings and environmental control

Cost savings were achieved by eliminating the need for expensive dredging to a more stable substrate; eliminating the need for trucking and disposal of the dredged spoils and; reducing the amount of imported materials required. The elimination of dredging greatly reduced the potential environmental concerns during construction.

b) Construction access
Access to the site of the barrier construction was a concern. Use of a barge launched from the beach area on the south shore was considered. However, this would be slow and the draft of a loaded barge would be too great for the shallow water depths in the vicinity of the barrier. Therefore, it was determined that access should be gained from the north shore. Although the slope is very steep, there is access via public lands and the selected route provided the dual purpose of forming a trail after use as a construction road. The barrier construction took place at the water level with stop logs out. Although excavation was not required, this minimized the potential for adverse machinery impacts and provided improved construction conditions.

After the construction of the barrier, water levels were raised and will remain at that level for at least a year to submerge the barrier enabling it to trap additional transported sediments. After that period, the water levels will be lowered by permanent removal of the stop logs.

In future, and in accordance with the longer-term phases, it may be necessary to assist the natural scouring process by dredging portions of the main flow channel through the reservoir.

Introduction of Wetland Vegetation

In 1995, during the reservoir rehabilitation study, reservoir water levels were controlled by notch openings in the reservoir sill (stop logs out) at 406.15 m above sea level (ASL). In areas of heavy siltation, shallow water depths prevented access by canoe to much of the area. The majority of the shallow area was unvegetated as a result of a combination of fluctuating reservoir flows, deep unconsolidated sediments, shifting substrate, high temperatures, and grazing by waterfowl, particularly Canada geese.

Following the rehabilitation study, stop logs were replaced, raising the water level to 406.6 m ASL. The extensive mudflat areas became submerged and were rapidly revegetated. This indicated there was sufficient seed material and adequate growing conditions within the reservoir to successfully accomplish the creation of a wetland area. Following the installation of the barrier to stabilize flow paths through the reservoir, plus one winter season, the water levels will be lowered to 406.15 m ASL. This .45 m drop of will reinstate the expanse of exposed areas observed in previous studies. Changed water levels will dramatically shift the location, structure and optimal growth conditions of the various existing aquatic plant communities. A planting strategy was designed to encourage native wetland community establishment and to discourage invasive plants. Plant selection was designed to minimize those favoured by Canada Geese and to reduce the amount of open water in the wetland area to attract other waterfowl.

The wetland community structure was divided into four vegetative groups based on preferred water depth ranges:
deep (>0.5m) shallow (<0.5m) saturated fringe upland floodplain
Several sub-groups were also identified as transition zones from one community to the next. These water depth ranges formed the basis for the ultimate planting plan.

Specific planting emphasis was placed on the areas where water depths would range from saturated to .25 m at the final water level. This zone, prior to water level drops would typically support deep water species. These areas

would be particularly susceptible to invasion of cattails and purple loosestrife.

Once the wetland has been established, pedestrian access trails are planned. A portion of the trail will be formed by the road constructed to permit barrier installation. A planting plan was recommended to stabilize disturbed areas of the road, renaturalize the trail, and create and maintain vistas of the reservoir and constructed wetland. Two additional trail paths have been suggested for future consideration to create additional access points to the wetland area and to provide a trail route around the reservoir.

Project Organization

The reservoir and surrounding lands are owned by the Town of Mount Forest. The Town, responding to concerns raised by the public, requested that the SVCA investigate the condition of the reservoir and make recommendations concerning its rehabilitation. The Authority hired a engineering consultant to prepare a rehabilitation study which was jointly funded by the Town of Mount Forest and the Ontario Ministry of Natural Resources. This study recommended the phased rehabilitation plan mentioned above. The existence of this study lead to the implementation of a pre-construction work plan that included additional design work, a campaign to raise public awareness, and an aggressive fundraising campaign. The SVCA was hired by the Town of Mount Forest to co-ordinate the implementation of the pre-construction work plan. It was funded entirely by the Town.

A Project Steering Committee was established very early in the process to assist the consultants, the SVCA and the Town. This committee is made up of municipal councillors, municipal staff, service club representatives and SVCA staff. The committee is chaired by a municipal councillor who also sits on the Conservation Authority Board of Directors.

Funds necessary for the construction of the wetland sanctuary were raised by the steering committee in the name of one of the local service clubs, due to its charitable status. When the required funding was raised the Town again hired the Conservation Authority to co-ordinate and manage construction. The SVCA was responsible for selecting a contractor for a portion of the work through a tendering process and for entering into an agreement for engineering supervision of the project. The Authority also entered into an agreement with the service club holding the funds to ensure that all SVCA contracting, engineering, and co-ordinating costs would be entirely reimbursed by the service club. Obtaining project approvals from various government agencies was also the responsibility of the project co-ordinator.

Community Involvement

The community has always been very much a part of this project. It was concerns originally raised by the community that started this project. The project steering committee is made up largely of non-elected community representatives and has been the lead group in seeing this project through to construction. In addition, the majority of money raised for the construction of the project has been raised from local groups, businesses and individuals. Some construction materials are being donated by local businesses.

The wetland planting and trail development portion of the project will require extensive community involvement in the form of labour. Service clubs and school students will provide the required labour to implement these portions of the project.

Project Funding

Total construction costs of the wetland sanctuary project will be approximately $200,000.00. This is a substantial amount of money for a town of 4,200 people. The steering committee established two types of fundraising to acquire these funds. Firstly there was local fundraising that was undertaken mainly by the service club representatives on the committee and targeted local industry, businesses, clubs, groups and individuals. It was found that this type of fund raising was best accomplished by local individuals who can draw on their extensive local contacts.

The second type of fundraising was applying to foundations, corporations and government agencies for larger sums of money. This form of fundraising is best done after local fundraising is well underway, or nearing completion, as many of the larger funding sources are more apt to fund a project that has financial commitments locally. Some larger funding sources match funds that are raised locally. The responsibility for acquiring money from these larger funding sources was given to the project coordinator using the resources of the local Conservation Authority. Numerous applications were made by the project coordinator on behalf of the charitable service club. These fundraising arrangements were found to be very successful.

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COMMUNITY INVOLVEMENT IN RECLAMATION AND URBAN ECOLOGY RESTORATION

Jannette Porter

Over the Fence Project

ABSTRACT

Grassroots Albany is an environmentally-conscious community group based in Toronto's Annex neighbourhood. A previously commissioned tree survey indicated the number of declining canopy trees in the neighbourhood. The Ecological Resource Group (ERG) was brought in to work directly with individual homeowners and provide organisation and expertise. ERG members encouraged the implementation of increased plant community types from ground level to forest canopy.

Project goals included increasing:

- urban vegetation / biomass
- the use of native species
- biodiversity
- the number of layers of urban vegetation
- the connections between natural systems
- custodial awareness of natural systems in land owners
- general knowledge of the complexity and importance of our urban ecology

During this two-year project, seventy-five neighbourhood households collaborated with ERG on plant selection and location. Nearly 2,500 native plants were introduced in this manner, demonstrating that what people do in their own backyard can have a direct, significant effect on the functioning of a healthier urban environment.

This paper addresses several issues -- in general, and as they apply to this project:

1.) challenging traditional landscape ethics and increasing the emphasis on environmental concerns

2.) native vs. non-native plants
   a) community awareness of native plants
   b) realities of the urban situation -- existing gardens of exotics

3.) community participation and thoughts on
   a) the development of a prototype so other communities can do this with less one-on-one assistance from consultants (e.g. ERG)
   b) fostering "ambassadors" in community groups to take on the consulting rôle

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Introduction

"If we become good stewards of neighbourhoods, we become good stewards of Earth."[1]

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[1] Vernon C. Brink, Preface, Naturescape British Columbia. The provincial guide.

Where the Annex is:
The Annex is a primarily residential area in central Toronto, just north of Bloor Street West. Our project concentrated on an area in the north-west corner of the Annex, between Bathurst and Howland Streets to the west and east and Dupont Street and Barton Avenue to the north and south respectively.

What the Annex is:
The Annex is a gracious neighbourhood of predominantly Victorian and turn-of-the-century homes with mature canopy trees and well-established gardens. The specific area of our project evidences the general pride of ownership of the residents in their well-tended gardens. It is mainly an upper middle class neighbourhood of professionals who enjoy the proximity of Toronto's downtown core -- employment, shops (especially along Bloor Street West), and other services. Although it is difficult to generalize based solely on the sample group to whom I spoke, it appears that Annex residents (particularly those who participated in our project) tend to show a keen awareness of the urban situation (e.g. pollution, environmental degradation) and feel a real sense of community.

Who is Grassroots Albany:
Grassroots Albany is a community group centred around Albany Street in the Annex. Its members are focussed on improving their local natural environment. This group, on its own, has initiated a number of environmental and ecological projects. The project that eventually evolved into 'Over the Fence', began with a pioneering endeavour for such a community group -- namely, the hiring of a forester to study the trees in the neighbourhood and to write a report on their health.

Why This Project:
Concern about the health and longevity of their mature trees prompted Grassroots Albany to commission the tree survey, which was completed in 1991. The author of the survey, Marshall Buchanan, found "there was a 50 year age gap between the existing overstorey and the next generation. In addition, the predominant species (Silver Maple) is aging, and many specimens are nearing the end of their average life span in an urban setting. Such invasive exotic species as Tree of Heaven represent a substantial proportion of the existing urban forest that is less than 30 years old."[2]

The tree survey gave focus to community action. People in the Albany area did not start out as advocates of native species, but evolved into such through the impact of the tree survey. The process of organising themselves, commissioning the report, and digesting its findings engendered a sense of personal attachment, ownership, and responsibility among the residents towards the neighbourhood's trees, their own urban woodland. No less important was their acquired, heightened sense of being part of a larger whole.

Who is ERG:
The Ecological Resource Group (ERG) is a voluntary, non-profit organisation founded in 1994 and dedicated to the improvement and understanding of urban ecology. Its membership during the period of this project was made up of community-oriented individuals with environmental backgrounds, interests, and skills. As an ERG member, the author has participated in each phase of the process in which ERG was involved.

Much of ERG's work began with the notion of an ecological quilt of linkages and evolved into the Living Links Programme, of which the Over the Fence Project was one. The linkage approach is essentially a holistic one, looking at how environmental factors both natural and man-made interact and affect each other culminating in (and often limiting) the ecology of any particular area. For example, a fence is not just a structure, but also defines a community, both human and otherwise. Once the fence is removed, it eliminates both physical and

[2] Mercedes Sawosch and Marc Willoughby, ERG Action 21 application

psychological barriers and gives rise to new interrationships. As can be appreciated, this can give rise to opportunities and challenges for a community that undertakes a naturalisation and regeneration approach.

How ERG became involved with Grassroots Albany:
A serendipitous meeting between members of both groups at the Royal Winter Fair Winter Garden show in the fall of 1995, convinced all concerned that working together on this project would be mutually beneficial and move the project forward.

Our Process:
1. Grassroots Albany started the ball rolling in 1995, by chatting with neighbours, knocking on doors, and leaving flyers at every door ("papering the neighbourhood").

2. Several months prior to the planting day of each year, a meeting was held in the neighbourhood to introduce potential participants to the project. At the first meeting, in February 1996, we concentrated on introducing residents to native plants and the ecosystem approach to doing plantings in their back yards. ERG and Grassroots Albany members provided a slide presentation and, along with other visual aids, gave general advice. In the second year, we encouraged participants to remove their front lawns and replace them with tall grasses, forbs, and ground covers at a workshop in November 1996. Grassroots Albany and ERG members led small group discussions on the project and provided one-on-one assistance to participants in completing their social surveys and selecting appropriate plants.

3. The social surveys furnished information on how residents used their yards (e.g. for entertaining), what types of plants they cultivated (e.g. vegetables) and what other factors affected their use of their yards (e.g. childern's play area or pets). These gave us some indication of the types of plants which would be appropriate to the site (e.g. no plants with poisonous berries in households with small children).

4. Homes were divided into "clusters" by block or side of the street. The first year, a pair of ERG members was assigned to each cluster and did site inventories on each back yard. Such features as planting beds, mature trees, decks, drainage patterns, sun/shade patterns, etc. were noted. In the second year, ERG members trained ambassadors to help residents with their site inventories. About 10% of resident-completed site inventories were submitted and the rest were completed by ERG members.

5. Plant material was selected by the residents from a prepared list in consultation with Over the Fence members. The lists were developed by an ERG member, who, through his work as a Landscape Architect, is constantly involved in naturalisation projects.[3] Particular attention was paid to including under-represented indigenous plants and those with high survival rates in urban settings. Residents pre-paid Grassroots Albany or ERG members for their plants.

6. ERG placed the plant orders with the various nurseries, with some plants delivered, and others picked up by ERG members. ERG also ordered mulch and topsoil.

7. Finally, we arrived at Planting Day. Planting Festivals were held on June 1, 1996 and May 24, 1997. People picked up their plants, mulch, and topsoil, mingled with neighbours, enjoyed donated muffins and juice, watched as then-mayor Barbara Hall planted a trillium in the local park, (May 24, 1997) and generally soaked in the ambiance of the gorgeous spring days.

8. Post-planting follow-up took place in fall 1996, spring 1997, and again in fall 1997, wherein ERG members assessed the progress of the plants.

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[3] Marc Willoughby, Landscape Architect, Toronto, Ontario

The Outcome:

In 1996, we had 54 households involved in the porject and 859 plants installed. The next year, the 60 households who participated planted almost twice as many plants as the previous year -- 1,625! This is especially notable given that there were only 21 newcomers the second year.

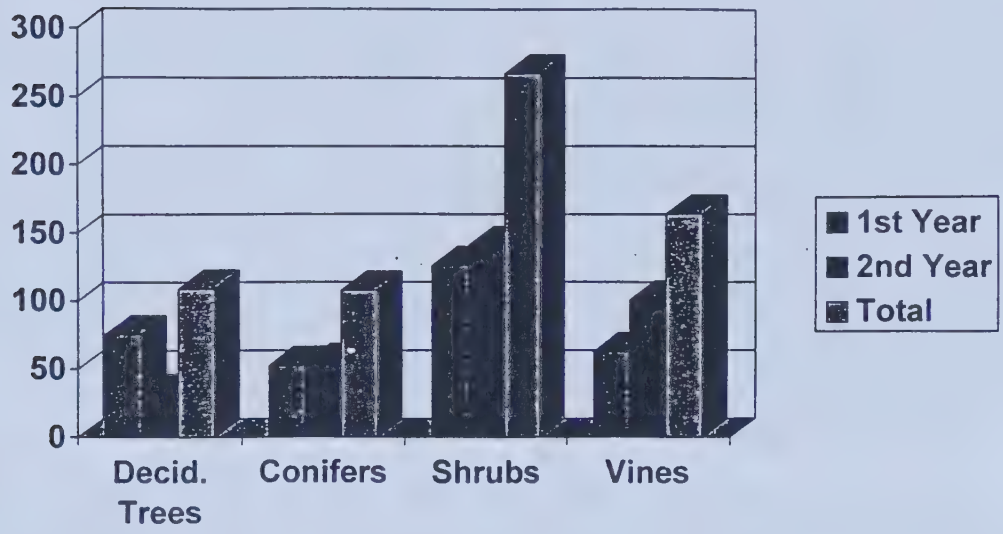


Figure 1 Woody Plants installed

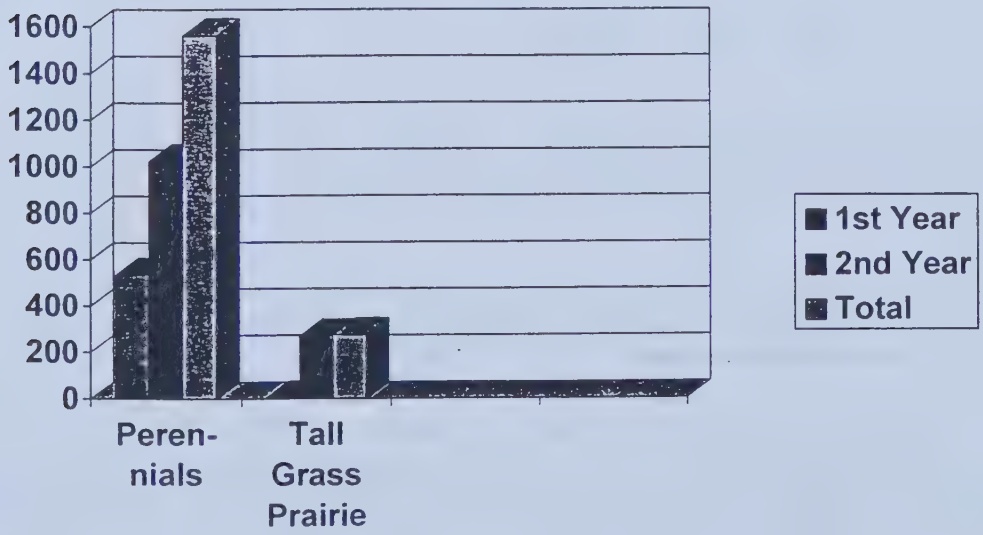


Figure 2 Herbaceous Plants installed

1. Challenging Traditional Landscape Ethics

ERG found that many residents were unaware of the environmental effects of design choices that they had made in the past and needed assistance in overcoming their reliance on what they had come to view as "tried and true." For example, tall prairie grass is not indigenous to the area, although there is some in High Park which is not that distant. But, at community meetings, ERG members pointed out that a tall grass prairie is superior to a traditional lawn in the following ways:

- better water infiltration into the soil
- more drought tolerant, so may help wean people of the habit of watering plants each day in the summer -- sprinklers left out for hours with water running off across the sidewalk, down the road and into the storm sewer
- creates wildlife habitat
- more visual interest/ variety, winter interest
- decreases lawnmower use, thus decreasing noise, fossil fuel consumption, and pollution
- its use demonstrates the value of education about ecological systems (e.g. forest, prairie, wetland) and indicates the usefulness of plants previously regarded as weeds (e.g. goldenrod)

No one jumped on the bandwagon to have a tall grass prairie front yard, but 219 tall grass prairie plants found homes in various gardens in the neighbourhood during the second planting day, May 24, 1997.

How native plants would look in the same garden with exotics was a concern with residents regarding any of the plants. We found it helpful to have pictures (especially those in colour) from books, catalogues, etc. When people can see a photo of a native plant (e.g. an Eastern Redbud) in bloom, chances are greater that they will be willing to plant it in their yard. Many see only a limited palette of plants that will survive in shade, when they contemplate the kind of continuous, vibrant colour only annuals can provide. But with a bit of work and creativity, (and encouragement from Grassroots Albany and ERG members) a woodland garden can be (and has been) created, with colour throughout the seasons.

Parking is at a premium in this neighbourhood and some front yards are completely dominated by parking pads. A possible future venture would be to encourage these householders to replace the pavers down the centre, where the car wheels do not touch, with ground cover plantings and use permeable pavers for new installations.

Fences -- everyone has a little plot of land to call their own -- fenced off from neighbours. Some of the older fences are old wire fences, probably from the 1940's or earlier, that are only 3 - 4 feet high, open, and support vines & shrubs. These fences allow a vista from one's back door, across several neighbours' yards, thus providing a sense of community, plus a sense of a larger world than just one's own back yard. In the last couple of decades, 5 to 6 foot high wood fences have become the rage, blocking out views of neighbours' back yard parties, sun, and views beyond one's own yard. In addition, most fences block the passage of small wildlife. By removing one or more sections of a fence, this passage may be enhanced. Furthermore, residents can still feel a sense of privacy yet feel a greater sense of community while having places where the vistas are greater.

Since this area is a bird flyway, we (Grassroots Albany and ERG) encouraged people to adopt plants that offered food and/or shelter. Otherwise, we did not strongly emphasise wildlife habitat for a couple of reasons, namely, this very urban area is cut off from other systems such as ravines, by the railroad to the north and major traffic thoroughfares in the other directions, hence, there is little mobility for wildlife. Also, we had no desire to increase the population of (or people's perception of such) pest animals, including racoons, squirrels, and skunks.

2. Native v.s. Non-Native

2. a) community awareness of native plants

In this neighbourhood, most people had some concept of what native plants are, although they would not necessarily know what particular plants were native to their area and climatic zone. One of the first tasks of ERG was to educate the residents in this regard. Early in the project, at public meetings organised by Grassroots Albany, ERG provided the participants with the native plant information. Through the use a slide presentation, followed by group discussions accompanied by photos and information on the specific native plants on our plant selection lists, ERG was able to sensitize the participants, both visually and cognitively, to the "native" options available to them.

Given the age of the neighbourhood and the profusion of established landscapes and active gardening, there was, of course, the recurring question of native vs. introduced ("exotic") plants, and which was preferable from an ecological versus aesthetic or cosmetic value. Some of the residents equated native plants with "wild" plants or weeds and raised the concern that native plants are, could or would become rampant and take over the garden. In order to deal with these concerns, ERG's educative process included disseminating information on the merits of native versus introduced plants.

We emphasised the following advantages of native plants:

- low (or lower) maintenance
- greater resistance to pests and diseases
- potentially higher degree of hardiness and rate of survival of native plants because they are adapted to local soil and climate conditions, with many also being tolerant of urban conditions (including pollution, salt, etc.)
- opportunity for conservation and preservation of some rare and endangered native species through the introduction or reintroduction of the plants to neighbourhood
- part of our natural heritage
- opportunity for variety (i.e. biodiversity) and beauty by the planting of native species which can be aesthetically pleasing and harmonious with the rest of the garden, blending in with the overall look of the neighbourhood (without being monotonous)
- opportunity to encourage a symbiotic naturalising effect on the overall environment as native wildlife, including birds, are attracted by native plants.

Just as important as having the knowledge and disseminating it as information, was the need to accept the residents' concerns as real, allowing them to articulate their fears without the danger of ridicule. Suffice it to say that some avid gardeners found it difficult to overcome what peers, gardening magazines, shows and garden centres had lead them to believe was a "proper" garden. And, in fact, ultimately not all of the neighbourhood participated in the native planting project. But, most did, with approximately 20 residents attending each of the 2 information sessions and 75 households participating in the plantings over the 2 years.

2. b) realities of the urban situation -- existing gardens of exotics

The position we took with this project was to work with residents' gardens as they existed -- native plantings could go alongside exotic plants in existing beds. If people wanted new beds, so much the better; they could be exclusively native. It does not necessarily follow that native plantings and exotics have to clash. ERG recognised that the "purity" of idea of native plant regeneration or naturalisation had to be tempered by the reality of the pre-existing gardens and therefore spoke in terms of biodiversity.

The realities of the urban situation demand what, indeed, will grow and thrive in urban conditions. This applies equally to native and exotic plants. Therefore, ERG evaluated all plants based on criteria such as the following.

Will the plants:

- tolerate pollution
- be appropriate size for small urban lots
- be appropriate for growth restrictions (e.g. not so tall they need to be disfigured to allow power or telephone lines to go through)
- tolerate being walked on

We took our cue from what was growing in the neighbourhood at the time. In other words, what survives? Then we balanced that assessment against the effect that the plant had or would have on other species. The Tree of Heaven (surely a misnomer, if ever there was one), *Ailanthus altissima* and Manitoba Maple, *Acer negundo* are pest species. They were found growing up in fences, against houses. Most property owners were unaware that these plants would become trees until it was too late and shaded out or out-competed the plants that surround them. As a result, the culling of invasive exotics became, along with turf removal, one of our goals in the second year. A further goal was the removal of dying or hazardous trees. A number of the mature Silver Maple, *Acer saccharinum* trees were in a state of decline and required removal of limbs. This tree work was completed in the spring of 1998.

3. Community Participation and Thoughts on

3. a) the development of a prototype

The strengths and weaknesses of any community-based project are determined by its membership. This is equally true of a residents group like Grassroots Albany as it is of a consultative group like ERG. As one member of Grassroots Albany put it, "you have work with the resources you have in the community"[4]. Consequently, the potential for success of any project depends to a large extent on the individuals within the community as to their experiences in life, what they have been exposed to and what their attitudes are.

Obviously, Grassroots Albany, or at least that part of the group who were its activists and opinion leaders, was aware of the limitations of its resources as it pertained to native plant awareness and expertise, which is why they sought to supplement their resource base by allying themselves with ERG. This showed a degree of self-awareness and sophistication that came from a fairly clear sense of direction, something that is perhaps not as evident in all community-based groups.

Appropriately enough, the analogy that the previously mentioned individual gave was a gardening one. An outside group (like ERG) can only sow the seed (the idea of doing a project like Over the Fence), but must allow the seed to be fertilised by the soil and germinate in its own way and in its own time by the members of any given community.

Symbiotically, ERG saw the Over the Fence Project as an opportunity to develop a prototype for other community-based naturalisation programmes, the idea of a prototype being a work in progress. Up to this point in the project, ERG was of the view that the prototype should include just the basics:

- the plant list
- social surveys
- a very straight-forward site inventory
- instructions on how to plant and maintenance
- contact with a group like ERG: - to train trainers with respect to site inventories and plant selection
  - to order plants and help on Planting Day

What the Over the Fence Project came to show, however, is that this minimal intervention by those in a consulting role does decrease the amount of control of the process. This may be seen as a conflict between two principles, one of the value of naturalisation and the other of empowering community involvement in all material aspects of decision-making. But, one has to recognise whose community it really is and accept that the empowerment of the community in reclamation and urban ecological restoration is a distinct value in itself, in the hope that, with educational opportunities, the longer term consequences of community empowerment will ultimately pay off.

In the short term, however, one may have to accept that there may be reduced environmental benefit: firstly, if residents choose their own plant material with minimal or no consultative supervision, the plant material may not be appropriate to the site, which may in turn affect survival rate. Secondly, there may be a decrease in demand for plants appropriate to the ecosystem in the neighbourhood. For instance, people may emphasise forbs and ground covers in their gardens and not include canopy or evergreens. We saw this in the second year of the Over the Fence Project even with our intervention. This is especially of interest given that the original purpose of the project was to increase the canopy. Only in the first year did people plant canopy trees to any

[4] Amanda McConnell, Grassroots Albany, Toronto, Ontario

Whether this was a loss of direction, a lack of consensus between the Grassroots Albany opinion leaders and the membership as a whole or merely a detour resulting from a realisation of the array of opportunities presented by the Over the Fence Project is difficult to say. But, it does raise questions about whether or not a need exists to continually reinforce the original objective or merely to recognise the political need for flexibility in order to accommodate as many interests as possible to maintain the sense of community involved (i.e. broad-based involvement) in like projects.

Nevertheless, whether with or without consultative intervention, a community planting project such as this proves itself beneficial in many ways:

- the residents' sense of community increased, developing a shared or common sense of purpose in a project like this, resulting in consideration of and, in some cases, implementation of the reduction of barriers (e.g. fences down) and the involvement in community events (e.g. meetings and Planting Festival/ Planting Day)
- there was a general sense of optimism in what could be achieved
- they developed or embraced an important connection with nature (i.e. "touch" nature, rather than being distant from it)
- they acquired a sense of stewardship of their environment as people became proud of their baby plants (nurturing) and were pleased to show people how their plants were doing, resulting of course in a real disappointment when a plant died. But, this too had a beneficial effect as they sought out the reason from ERG as to the possible causes of the mortality, evidencing a pro-active approach, rather than a fatalistic, defensive or accusatory approach, although they did sometimes sometimes become frustrated by outside forces (e.g. squirrels chomped off trilliums, the wet summer causing the trees to suffer). But, the more stalwart realised that this was also part of their relationship with nature.
- they developed a community of knowledge and experience which they came to respect and share. Piles of compost and mulch placed on driveways for them to access became gathering spots not just to load up one's wheelbarrow or bucket with growing medium, but for neighbours to visit and trade gardening pointers. This also occurred a the pick-up points for the plant material (in other neighbours' driveways).
- they developed a sense of pride in their own contribution to the environment and, perhaps more importantly, a realization of their ability to make such a contribution. They were proud of what <u>they</u> themselves have done. For although ERG and Grassroots Albany members provided them with opportunity and assistance, the householders themselves chose and installed their own plants.
- biodiversity, biomass, forest structure and native plant proportion components were improved
- awareness of urban forest issues were promoted outside the community through the media
- the hiring of part-time labourers (to lift turf and assist with planting) created employment benefits

3. b) fostering "ambassadors"

A project like Over the Fence could be taken on by any existing community organisation, since these organisations already have the infrastructure and the people with energy and commitment.[5] It is not far-fetched to believe that groups such as ratepayers associations, boys and girls clubs, church groups and even daycare centres could become involved in this kind of project, thereby turning community involvement into ecological action. As with any volunteer endeavour, those involved want to be assured there are people willing to help.

Community involvement means volunteers, means commitment (time, energy, communication -- getting the word out about the project).

When volunteers are being relied upon to do the work, there are a number of attendant problems. The number of volunteers and their level of commitment will likely ebb and flow. There must be facets of the project that keep up their interest levels. Nevertheless, volunteers' energies will not always remain high. Our project went great guns for 2 years and the major volunteer contributors spent many long hours on it. It was decided at the end of the second year to take a break, simply supply native plants to an existing annual sale of perennials in the spring of 1998, then return to Over the Fence for spring of 1999.

One approach is to keep the project simple. A reduced amount of work that does not burn out the volunteers and has a minimal number of problems is ideal. (This may be easier said than done.) We will be instituting a number of changes to simplify the process leading up to Planting Day, 1999 to test this theory. Because we hope to attract more participants by increasing the geographic area, ERG members will not be doing site inventories and consultations for plant selection with each homeowner. Instead, these services will be made available for a fee and Grassroots Albany will be training residents how to do their own site inventories. (These will be much simplified versions of those previously done.) We have high hopes for these changes.

If, indeed, these changes are effective, it will give further impetus to use of the prototype in other communities. Several of us, who have informally discussed the Over the Fence project with others from other communities have received expressions of interest. "How can we do this in my neighbourhood?", is what we are asked.

It is important that the project be made fun, not just for the participants, but also for the volunteers.

According to a friend of mine, whose masters thesis in Environmental Studies focussed on environmental education:
education alone does not always accomplish an objective;
grassroots involvement alone does not always accomplish an objective;
but by combining the two, you create opportunities that are fun and therefore encourage greater participation, thereby increasing the probabilities of being able to accomplish the objective.[6]

If, as one resident says, she became an advocate of native plants due to the tree survey and this project, the scope of educational opportunities for a project like this are encouraging.

[5] Amanda McConnell, Grassroots Albany, Toronto, Ontario
[6] Kate Oxley, MES, Toronto, Ontario

Conclusion

"Though every site is unique, with its own ecological design considerations, 'Over the Fence' has demonstrated that the urban ecology of a neighbourhood can be improved at a community scale and across fragmented private lands, by tying those fragments into overall ecological goals and patterns."[7]

We **cannot recreate** the forest in an urban residential area. The reality of buildings and hard pavements (road, sidewalk, driveways, parking pads, walks) do not enable that many trees to be that close together as in a forest. A further reality is how many and what kind of plants people are comfortable with on their property. As it is, Some householders do not wish any further shade on their gardens; they feel there is not a good selection of plants for these conditions. Not everyone has shade, so there is an opportunity to create a meadow, or a wetland in a low spot.

A project like Over the Fence demonstrates there are many alternative plants to the traditional annuals and exotic shrubs and perennials that may be grown in shady, forest-like conditions. Plants from forest ecosystems may thrive here. This includes plants from all of the strata in the forest: canopy, understorey, shrub layer, herb or ground layer, and forest floor. When a participant is willing to install native plants in all of these layers, it is very exciting.

The success of the first year of Over the Fence and the enthusiasm with which it was greeted by participants and would-be participants alike, encouraged Grassroots Albany and ERG to embark on a second year. More than half of the Year 2 participants were "repeat customers". We look forward to building on these foundations, to develop a prototype so that volunteers in other neighbourhoods may participate in an ecologically meaningful and enjoyable project such as this.

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[7] ERG flyer

Community Involvement in the Restoration of High Park

Christopher Harris

Co-Chair, High Park Volunteer Stewardship Program

ABSTRACT

The High Park Volunteer Stewardship Program (High Park VSP) is a volunteer led community initiative whose purpose is to restore the ecosystems of the natural areas of High Park to presettlement conditions. The group works in partnership with the City of Toronto Parks and Recreation Department in this endeavour.

This paper provides an overview of the inner workings of this volunteer organization, from planning to operations, including our participation in restoration events and how we communicate with the public. It provides some perspective on why we have been successful, our accomplishments and learnings. It also provides some insight into the challenges and opportunities for growth.

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1 Introduction/History

1.1 Natural History

The Toronto area is unique in that it sits in a transition zone. As a result, it includes vegetation characteristic of the Carolinian forest region, Great Lakes-St. Lawrence forest region, and Deciduous forest region.

The 399-acre High Park is a bio-island, being the last sizeable natural area remaining on Toronto's Iroquois Sand Plain. These sands were laid down on the shores of glacial Lake Iroquois, the larger version of Lake Ontario, that was formed when the glaciers retreated from our area 12,800 years ago[i]. As Lake Iroquois receded, the Iroquois Sand Plain in High Park was modified into flat and rolling uplands and ravine bottomlands. An extensive watershed of ponds and streams was also created.[ii]

High Park is made up of a unique combination of vegetation communities. These communities include the remnant woodlands and Oak savannahs of widely spaced oak trees, low shrubs and prairie grasses in the upper table lands; the red oak, cherry and maple forests of the lower slopes; the mixed forests of hemlock and red oak in the ravine bottom lands, and the park's ponds and associated wetlands and streams.

High Park still supports a remarkable assemblage of rare flora and significant vegetation communities. They include four nationally/provincially and thirty-seven regionally rare plant species. About 125 acres (30 per cent) of High Park is considered ecologically significant based on extensive studies by the Ontario Ministry of Natural Resources. These are made up of 110 acres of oak woodlands and 15 acres of marshlands. High Park has been identified as an Area of Natural and Scientific Interest (ANSI).

1.2 Toronto Parks and Recreation Involvement in High Park

In 1873 John Howard deeded his property to the City for use as a public park by the citizens of Toronto. With the exception of Colborne Lodge and a small farming operation, this land was in a relatively natural state. Over the next century, the City's development of the park included: roads and parking lots, restaurant and concession facilities, a zoo, playgrounds, a greenhouse and work yard, allotment gardens, recreational facilities and picnic areas, ornamental gardens, groomed turf areas, walled revetments along the pond shorelines, and more. The park evolved to meet the demands, public sentiment, and management practices of the day.

Starting in the mid-1970s, things began to change. Around 1974, the City realized that the natural environment of the Park represented a key asset and began to reduce mowing in order to encourage and preserve the Oak savannah. In 1976, the Ministry of Natural Resources conducted an ecological Study of Grenadier Pond and the Surrounding Areas of High Park under the supervision of Allan Wainio. In 1986, the City Parks Department undertook a survey of the Ravines of Toronto and produced working plans to address their rehabilitation and preservation. The High Park Ravine (included the Savannah as well) study was completed in 1988 and recommended further reduction of mowing practices in order to encourage the regeneration of the Black Oak Savannah vegetation. This recommendation was implemented. In addition, the propagation of native woody plants was recommended and the native plant propagation program began at the High Park Greenhouses.

The Department initiated a further study in 1988 with the purpose of developing a comprehensive management philosophy that would guide the implementation of appropriate park stewardship. This study included all aspects of High Park: transportation and traffic flow, safety and recreation, the natural environment and virtually all aspects of park use, development and maintenance. At the request of Parks and Recreation, Steve Varga of the Ministry of Natural Resources (MNR) conducted a Botanical Inventory and Evaluation of the High Park Oak Woodlands in 1989. His recommendation resulted in High Park being identified as an Area of Natural and Scientific Interest.

In response to this report, the City initiated a broader study (than the original done in 1988) of the Park, concentrating on regeneration and restoration techniques. This was conducted by staff of Parks and Parks Planning sections. A report, *High Park: Proposals for Restoration and Management and Framework for Restoration*, issued in draft form in May 1992, was subjected to extensive public consultation over the summer and was adopted in a revised form by City Council in February 1993. This report recognized, among other things, the importance of High Park's natural areas and delineated an approach to the restoration and management of these areas. This approach was approved in principle by City Council.

In 1991, herbaceous native plant propagation began at the High Park Greenhouses on a limited basis. By 1995, it had expanded considerably. In 1996, a concerted effort began to establish a native plant nursery both as a source of plants and seed and as a demonstration site and educational resource.

Recognizing the critical need for on-going, systematic and broadly representative community input and consultation, the Parks Department recommended the establishment of a High Park Citizens' Advisory Committee (interim) which was approved by City Council in February 1993 and became a permanent Committee with the approval of its Terms of Reference in September 1995. This Committee, of which the High Park Volunteer Stewardship is a part, plays a key consultative role in the management of High Park.

Out of the proposals for restoration and management came the High Park Oak Woodlands project. Its objectives included:

- characterizing the historic land-uses and evidence of factors leading to present conditions of the significant oak woodlands of High Park
- characterizing key quantitative and qualitative variables to document existing ecological conditions of the significant High Park woodlands, and
- providing basic information useful in the design of programs of restoration for significant oak woodlands[iii]

The consulting firm, Applied Ecological Services Inc (led by Steven Apfelbaum), was retained by Parks and Recreation to conduct a detailed restoration strategy study in 1994. This study resulted in a better understanding of the Oak Savannah system and outlined a Test Plot Program that would measure the effectiveness of proposed restoration techniques. In addition, conducting limited tests would serve as a barometer of the public's

acceptance of such measures. This program was implemented in 1996 by Parks and Recreation in partnership with the Volunteer Stewardship Program and is on-going.

In support of its studies and initiatives, Parks and Recreation drew together a group of technically skilled individuals as an informal consultative body to comment on various matters relating to the High Park Oak Woodlands; Pond, Wetland and Stream; and Ravine Ecosystem research and work. This group, called the "Technical Resource Group", is composed of Parks and Recreation staff and many experts drawn from various organizations and agencies in the Toronto area. The Department continues to draw upon this valuable group of professionals and volunteers.

Over the past ten years, Parks and Recreation has increasingly encouraged the participation of the public in promoting the significance of High Park's natural areas and their involvement in restoration and management activities. Major initiatives that provided opportunities for participation have included Pond and Wetland rehabilitation around Grenadier Pond, native plant production in High Park Greenhouses, Black Oak Savannah restoration and Test Plot work. Forest management in the Ravine areas of High Park will be implemented in the autumn of 1998 and will represent yet another such opportunity.

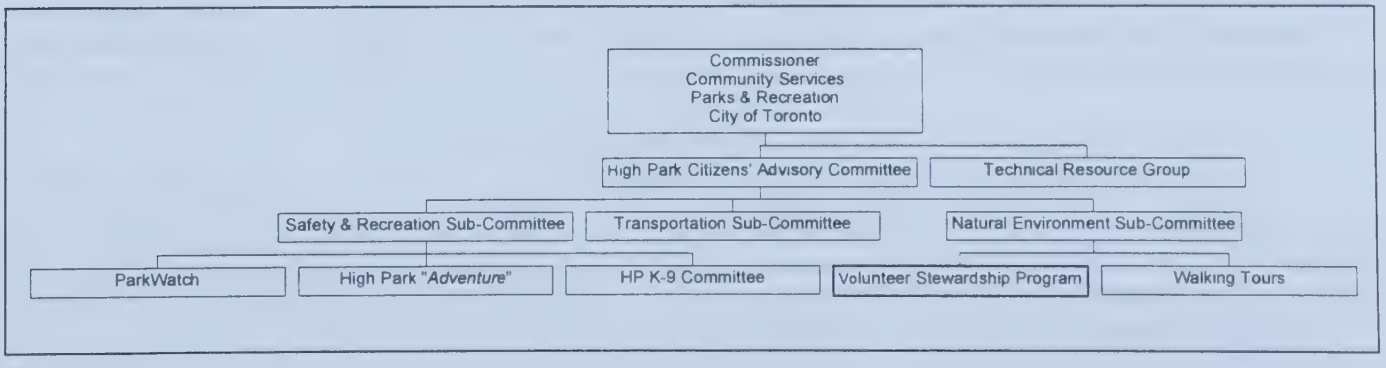
1.3 Community Involvement in High Park

In the late 1980s and early 1990s, community interest was growing within the High Park area to balance conflicting uses of the park, provide input into Park restoration and management, and to generally learn more about the natural and human history and flora and fauna of the park. Although advisory councils were well established for recreation centres, no similar citizens' forum was common for parks.

In January 1992 the community raised some major concerns in regards to the removal of trees (deemed a safety hazard). This concern resulted in a meeting between members of the community and Herb Pirk, Commissioner of Parks for the City of Toronto. The meeting and continuing discussions accelerated the release of the previously mentioned *High Park Proposals for Restoration and Management* and the establishment of the Citizens' Advisory Committee. Since that time the High Park Citizens' Advisory Committee (HPCAC) has grown and evolved, fulfilling its mandate of providing the Commissioner of Parks and Recreation with on-going public input and assistance in all matters concerning High Park.

Membership of the HPCAC is made up of: ratepayer and resident associations, recreational stakeholders, long term interest groups, business and park entrepreneurs, as well as community residents. The HPCAC has three sub-committees that provide input on different aspects of park policy and use: Safety and Recreation, Transportation, and Natural Environment. The High Park Volunteer Stewardship Program (VSP) is a sub group within the Natural Environment sub committee, as highlighted in our organizational chart below.

Figure 1 – Structure of the High Park Citizens' Advisory Committee



1.4 Birth of the Volunteer Stewardship Program (VSP)

The High Park Volunteer Stewardship Program was launched over two years ago on June 19th, 1996, and was one of the first initiatives of the formally established Citizens' Advisory Committee. Looking back, the birth and rapid development of the Volunteer Stewardship Program was in large part due to work initiated by Parks and Recreation at the High Park Greenhouses in 1991. Anticipating the requirement for native plant material, the department encouraged some of its staff to determine how to best propagate and reintroduce native plants to High Park. The efforts of staff were discussed at the Natural Environment sub-committee meetings. It was at these meetings where the concept of a volunteer organized restoration group was also first raised. The partnership between the community and the Parks and Recreation department seemed like a natural fit. Terry Fahey, a member of the High Park Greenhouse staff, was involved in the exploratory restoration work that the Greenhouses were performing, and was able to obtain native plant material and lead us in our early restoration activities.

Our first volunteer event was preceded by considerable discussion on how we should undertake restoration efforts in the park, and how we should best organize our efforts. Faced with the fact that there was no established formula for restoration within the park, we decided that we would learn through our experience, and shape and mould the program as we learned. It was with this optimism that we embarked on our restoration efforts, and our group grew from there.

2 What We Do

The purpose of the Volunteer Stewardship Program is to restore the ecosystems of the natural areas in High Park to presettlement conditions. We work with the City to plan, coordinate, and implement restoration activities in the park, we facilitate community involvement in the park, and we educate the public and communicate our efforts.

We support a variety of initiatives such as the Oak Woodlands Test Plot Program (mentioned earlier) through our Sunday afternoon and Wednesday evening restoration events. We have also developed Scout and Guide event days, as well as special events associated with Earth Day and Harvest Festivals in High Park. Our goal is to develop the knowledge and expertise of our volunteers in all aspects of ecosystem restoration, to become a model for community involvement in ecosystem restoration, and to apply the knowledge gained to the restoration of High Park.

Our restoration activities run throughout the year, and vary depending on the season. Our activities include planting, removal of invasive weeds, brushing, seed harvesting and cleaning, and plant propagation in the Greenhouse. Controlled burns are managed by the Ministry of Natural Resources, and the seasonal level variation of Grenadier Pond is managed by Parks and Recreation staff.

3 What We Have Accomplished

At the end of 1997 we had 135 active volunteers. As of July 1998, this number now stands at 200 volunteers. During 1997 we:

- invested 1,900 person hours in the park (roughly one person year)
- worked with Parks staff to develop a 1997 restoration plan
- propagated 4,700 containers of native plants
- reintroduced 7,600 native plants
- removed innumerable stands of weeds
- organized and led two Scouting activity days
- assisted the TRCA with their school pond planting program
- made several presentations on our program to interested community groups

The efforts of our group have contributed to the reintroduction of regionally rare and extirpated species such as Stiff Gentian, Butterfly Milkweed, and Spiked Liatris to the park.

In 1997, we also launched an Adopt-A-Plot program, which provides an opportunity for groups to focus their restoration efforts on a specific area in the Park. Our program develops a restoration management plan and provides plant material, tools, and instruction on the group's restoration activities in consultation and partnership with the High Park Greenhouses and operations staff. The Adopt-A-Plot program enables the group to show up on their own schedule and manage their own time.

We are currently working on roughly 20 different sites within the park, with many on the order of 1000 square feet. Several sites run 2000 to 3000 square feet. At this point we are still experimenting with various techniques, in an effort to increase our efficiency and thus the area under our stewardship. We will likely always be constrained by the time required to plant native plants, but are looking to develop effective methods for the control and elimination of invasive weeds.

For purposes of reference, it is helpful to compare us to other volunteer groups in Toronto. The High Park Volunteer Stewardship program is the largest volunteer organization in Parks and Recreation for the former City of Toronto. For comparison, an area that draws a significant number of volunteers is Health Care. The Toronto General Hospital has 700 volunteers and is well known and well established. The fact that we have grown to 200 active volunteers in only two years is a testament to the public's interest and appetite for the environment and restoration. We are also likely the largest volunteer led volunteer organization in Toronto, and in partnership with Parks and Recreation, organize and manage one of the most successful restoration activities in Toronto.

4 Operations

Being a volunteer group led by volunteers, we must maximize the return on our personal time in the organization and implementation of our efforts and activities. Simplicity (including ease of managing the program) and consistency is the key to our operations.

Our events are run every other Sunday year round at 10:30 am and are 2 ½ hours in duration. From May through August, we add an evening event every other Wednesday at 6:30 pm, and we gather at the south entrance of the Grenadier Café and Tea House prior to our events.

We run announcements of our events in the community newspapers and publications such as NOW Magazine, as well as in our local councillor's calendar of community events. We have expanded our announcements to all of the Toronto and ethnic newspapers through the Toronto Digest, a weekly publication of events compiled and distributed to all of the news services by Toronto City Hall.

Ours is truly grass roots marketing. We have no brochures on our group but with the assistance and support of Parks and Recreation we distribute our latest newsletter to potential volunteers. We have not held any press conferences to promote our efforts, and we have no formal marketing plan. Over and above our announcements in local newspapers, our volunteer base has grown through word of mouth.

5 Planning

We have a core group that is responsible for planning all of our events. This core group is made up of the "original seven" that embarked on the vision of community based restoration in High Park over two years ago, and we act as the catalyst, driver and cheerleader for the program. Tony Jovan, David Kirkpatrick, Ron Luft, Terry Fahey, Kathleen Keefe, Ron Allan, and myself make up the original seven. In addition to the original seven, other people, such as Charles Kinsley, have joined us. We come from all walks of life and experiences.

Several of the core group are very knowledgeable in native plants, while some of us have no formal training but bring enthusiasm, organizational, promotions, and leadership skills.

Annually we discuss projects or areas of the park that each of us has an interest in pursuing. At a high level, we plan the activity for each event, such as plant propagation, transplanting, planting, weeding, buckthorn removal, etc, at least 6 months in advance. We get together monthly at one of our homes to plan the specifics around the upcoming month's events. Rounding out the group on the planning side are Arthur Beauregard, Coordinator of Plant Production for the High Park Greenhouses, Carol Walker Gayle, Urban Forestry Planner, and Carol Guy, Supervisor for High Park; all from Parks and Recreation. Although the Parks and Recreation folks may not always join us at our planning sessions, we gather their input for discussion at our meetings.

Our future activities are often predetermined by our earlier initiatives. For example, many of our events involve maintaining previously planted areas with weeding and watering as necessary. Only as our volunteer group grows, or the areas under our management are well along the road to being restored, do we expand our efforts to new sites. We have learned through trial and error the capabilities of volunteers, Parks staff, and the park environment itself to adapt to the challenges of restoration.

At our monthly meetings, we plan the details associated with the upcoming events. Planning details range from the specific area in the park that we will be working, to the techniques that we will employ and the tools that we will require, to provisions for plants and specific plant material that we would prefer for that area, to watering and the removal of bagged weeds, etc.

Our monthly planning sessions are critical for sharing information, evaluating the success of our past month's events, discussing ways to improve our events based on volunteer feedback or perceptions, and brainstorming for special events. These sessions are also important for reconciling differences of opinion on how we should approach our work. For example, should we focus on removing invasive weeds from all of the richest native plant sites around the park, or should we instead focus on eradicating weeds from one area or adjacent areas and gradually increase their size over time? This means trading off long term progress against the decline of some of the loveliest areas within the park. Or trading off the fact that by maintaining the richest areas of the park we are simply removing the weeds that blew or crept in from the year before, and merely holding a defensive position, a stalemate, against the onslaught of non-native plants. These philosophical discussions tend to be very passionate and emotional. I think what keeps us together and makes us successful is our respect for each other, our willingness to discuss issues where we know that we have differing opinions, our willingness to try new approaches, and the fact all of us share a common purpose and understand that there is no set formula for success. Our experience has shown that a technique that may have phenomenal results in one area of the park may indeed be a stunning failure in different area of the park. Experience, persistence, observation, and experimentation have been our greatest teachers. Friendship and our love for the park have been our binding and driving force.

Potential restoration activities must meet several criteria before they can be seriously considered as events:

- The restoration activity must be meaningful for the volunteers. In other words, volunteers must leave the event with a sense of accomplishment and satisfaction.
- We must be able to impart the necessary knowledge or skills to be used for the activity in a few short minutes, or have enough experienced volunteers to mentor and guide new volunteers in the activity
- We must be able to achieve a set objective within the 2 ½ hour activity (event) period
- We must be able to point to a long-term contribution of our two hour event. We must make tangible progress upon which we can build successive events.

If a restoration activity or environmental challenge fails these criteria, we discuss alternate management techniques that could be employed by volunteers or Parks staff to meet the challenge. Events that have failed our criteria include the removal of purple loosestrife and black swallowwart (dog strangling vine) on a large scale, and the removal of Japanese knotweed. Potential management techniques that are being discussed or have been employed to meet these challenges include the introduction of beetles to control loosestrife, the reintroduction of mowing to control swallowwart, and an experiment to monitor the success of monthly pulling of knotweed in a defined area. Thus in spite of the fact that a restoration activity or challenge may be too great around which to build an event, we can often develop some creative alternatives to meet the challenge, in partnership with Parks and Recreation staff.

6 The Event

We always attract new volunteers to our events. New volunteers can make up anywhere from 10 percent to 50 percent of the group at any event. We begin each event by having each person introduce themselves. We always have a member of Parks staff with us to support the event with plant material, tools, water, and their knowledge and enthusiasm. Following introductions we provide an overview of the work to be performed for that event. At that point we depart for the location where we will be working.

During the walk to our destination, we take the opportunity to welcome the new volunteers, make them feel comfortable, and find out how they learned of our efforts. Upon reaching our destination we evaluate the success of our past events focused at that location, discuss the techniques that have been previously employed, why they have been employed, the results that we are trying to achieve long term, and our objectives for this specific event. We then provide some pointers on the practices that we will employ that day. For a planting event this might be as simple as providing information on the clustering of certain plants, the plants' shade tolerance, and instructing everyone to leave the empty containers next to their planting, so that the person watering can find their plant.

We partner up new volunteers with experienced volunteers, to help the new volunteers apply the techniques that we have discussed and to answer their innumerable questions. Our experienced volunteers are the ones best suited to answer questions, demonstrate techniques one-on-one, and provide their personal perspective on our activities. Our experienced volunteers embody the spirit, enthusiasm, and living knowledge of our group.

The involvement of Parks and Recreation (including Development and Support, Forestry and Parks Operations and Greenhouse staff) at our events is extremely important. The staff member supporting the event (if not already well versed) is briefed on the event, the objective and techniques to be used, in advance of the event by the appropriate Parks and Recreation person. These events have evolved as true partnerships with leadership and expertise being, in general, equally present and exercised by Parks staff and key volunteers. This is beneficial for the members of the core planning group by ensuring that there is never an obligation for members of the group to be present for any given event. This is also beneficial for staff members new to volunteering, in that they get the opportunity to build their skills by working with a large volunteer group while being supported by the more experienced volunteers. This builds a strong sense of ownership and belonging by all involved.

Other important aspects of our events:

- The social aspect, the sense of community and purpose and belonging, is crucial to the on-going success of our efforts
- We draw people of all ages, from teens to retirees, and families as well. We have volunteers from diverse cultures and backgrounds, from across the Greater Toronto Area (GTA).
- There is never an obligation to attend an event, nor is there a log kept of people's participation
- We celebrate the success of the group on our anniversary in June and at a year-end event in November. Contrary to other volunteer groups, we do not recognize the contributions of individual volunteers. The

feeling is that we all contribute as our personal time permits, and that everyone is always welcome, whether they are a new volunteer, a regular, or not so regular volunteer. Every one makes a difference.

- The events are free fun, free entertainment
- Many of us work to remember everyone's names and to welcome back each new volunteer by name at the next event they attend

7 Communications & Promotions

Many volunteers come out on a seasonal basis. Some prefer to work in the Greenhouse propagating plants in the winter and spring, while others prefer to get involved in the summer. In order to keep in touch with all volunteers, we publish a newsletter at the start and middle of each year, which is reproduced and distributed by Parks and Recreation. The newsletter includes a calendar of events for the upcoming six months, our accomplishments over the past six months, as well as an overview of some of the new projects and initiatives under consideration.

In order to effectively manage our volunteer group, we developed a form to capture their specific interests with regard to restoration, event organization, and their desire to get involved in other activities within the park. We have used this information in the past to personally call each volunteer regarding upcoming events, or to enlist their involvement in specific activities. We also share this information with other High Park Citizens' Advisory Committee (HPCAC) groups in which the volunteers have expressed an interest.

We have established a post office box for the return of volunteer forms, and have an information line provided by Parks and Recreation with a recorded announcement on upcoming events. The information line is common to all of the volunteer groups operating in High Park, and enables callers to obtain information on upcoming Walking Tours, Volunteer Stewardship events, information on Park Watch, and general park events.

We are able to leverage the strengths of the HPCAC by highlighting our efforts at each of the highly successful High Park Walking Tour events. These tours are led by scientists, artists, and naturalists, and focus on such themes as the influence of High Park on Canadian Art, Bat Night, Grasses, Native Flora in a Carolinian Forest, Prose and Poetry in the Park, and more. Those expressing an interest in our VSP program are provided with a volunteer form that they can fill out and return. We also are involved in the training of Park Watch volunteers. These volunteers act as park hosts, providing direction and assistance to the public, and act as eyes and ears for Parks and Recreation staff and Toronto Police.

In order to build awareness and support for our efforts at a political level, we provided a presentation and information package in late 1997 to our incoming City of Toronto councillors. This was done as part of a larger presentation by the HPCAC to educate the councillors on our group, our efforts, the challenges that surround our programs, and the areas for which we would be looking for their support.

One of the most important exercises that we undertook when launching our volunteer program was to develop a vision statement and strategy for our group. This not only served to build consensus and focus our efforts and purpose, but also enabled us to clearly articulate our mandate to new volunteers, Parks and Recreation staff, the public and the media.

8 Why We Have Been Successful

First and foremost, we have been successful because of our partnership with the City of Toronto Parks and Recreation Department. The partnership is especially successful because both groups complement each other so well. In Parks and Recreation, we have a group that has demonstrated its commitment to capital projects and initiatives that support restoration in the park. During times of fiscal restraint, however, this group's resources have been reduced. In the Volunteer Stewardship program, we have a significant group of people committed to

dedicating their time to restoration activities in High Park. Both sides bring an extensive knowledge of native plants, propagation techniques, and a personal desire to see our efforts successful.

Building on the partnership, we have been successful because we have been able to collaborate on our efforts and initiatives. As we well know, there is no formula for restoration. Success comes through experimentation, observation, patience, and a willingness to learn together. We share a common purpose and desire, and have been able to build a sense of ownership and meaningful volunteerism. We have been able to learn of each other's challenges and limitations, and by doing so, develop some creative solutions for overcoming those hurdles, thus making us stronger through our partnership.

Another key to our success has been the education of our volunteers. During the winter months we have worked with Parks and Recreation to run training sessions on plant propagation techniques, and look back at the conditions to which we are trying to return, through archival pictures. We learn through osmosis and the sharing of knowledge. At the beginning of every event, we review the objective of that day's efforts, the techniques that we will apply, the rationale for their application, and results that we have observed around the park. In addition, by partnering new volunteers with experienced volunteers at our events, we are able to quickly build the skills and basic knowledge of all volunteers.

A significant development has been our ability to work in the High Park Greenhouses during the winter months. It has enabled us to maintain momentum, continuity, and enthusiasm of the volunteers by keeping them involved year round. It has also allowed us to work on the full cycle of restoration, from seed collection to plant propagation to the reintroduction of plants into the park, reinforcing the sense of ownership.

Another reason for success has been the public's appetite for anything associated with the environment. Not only has this enabled us to attract volunteers in large numbers who have an overwhelming desire to learn and contribute, but it has also enabled us to attract highly knowledgeable and skilled individuals interested in the organization and evolution of the program. This has resulted in a continually improving and well run volunteer program, and a group eager to address issues as they arise.

We have also been successful because we respect the value of everyone's time and commitment. We have refined our events so that all of the plant materials and tools that we require are awaiting the volunteers when they arrive. The location that we are to work in has been evaluated and the work carefully planned. Annoyances such as Poison Ivy are avoided wherever possible, and pointed out when in close proximity. Volunteers are comfortable leaving our events when ever they need or choose, and if the weather is too hot, too cold or too wet, we will often pack up early and head over to the Grenadier Café and Tea House for some refreshment. In spite of the fact that we are serious about the restoration of the park, it is also important that we have fun and enjoy the work that we are doing. It should never be felt to be a burden.

At a very high level, another reason for our success has been the High Park Citizens' Advisory Committee's ability to reconcile divergent points of view. Discussion now occurs at the community level before proposals and recommendations are forwarded to Parks and Recreation, and all individuals and groups in the community must build support and gain consensus on views and direction. Without this support and willingness to become part of the solution, unpopular views are put in perspective and addressed by the community. This not only provides Parks and Recreation clear direction from the community, but also provides them with a forum for the discussion, review, and support of new ideas and initiatives.

9 What We Have Learned

We have learned a great deal through the efforts and results of our first two years and through the High Park Citizens' Advisory Committee as well. Restoration is no longer a political hot potato. A large group of people has put their time into the restoration of High Park, and the media has supported our efforts through the positive

reporting on potentially controversial initiatives such as the controlled burns of the Oak savannah. The well organized High Park Citizens' Advisory Committee serves as an effective and respected public and community forum on issues that face the park.

There has been growing support and an overwhelming success for restoration in other cities across North America. Chicago has restored hundreds of acres under the stewardship of volunteers[iv]. Mayor Richard M. Daley has been a supporter of restoration within the city. Native plants can be found on the medians around the city and down the centre of LaSalle Street just outside City Hall[v]. US President Clinton passed an Executive Order on April 22, 1994[vi] regarding the use of native plants. It directs all federal facilities and projects to plant local native species wherever possible. In addition the Agriculture Department is directed to conduct research on the suitability, propagation, and use of native plants for landscaping. The order also calls for outdoor demonstration plots to promote public awareness of native plants.

The attributes of native plants, including their disease resistance, lack of nutrient, water and pesticide requirements, and success in the reduction or elimination of run-off problems, etc are significant benefits[v], and create a strong economic argument for their widespread use.

10 Challenges & Opportunities

We are always looking forward to how we can improve our volunteer program. These are some of our challenges and opportunities:

- Impact of amalgamation within the City of Toronto on resource allocation for regional parks

  The Parks and Recreation Department within the City of Toronto has been undergoing budget cuts since the early 1990s. Parks and Recreation have worked to maintain their efforts in restoration, but even this has seen a reduction in staffing levels. Without the continued commitment and on-going support from Parks and Recreation staff, the efforts of our volunteer group will be adversely impacted.

- Visibility of and commitment to the importance of restoration and naturalization in the City of Toronto

  The City of Toronto does a wonderful job on capital projects and project management initiatives. These get funding dollars and visibility at City senior management levels. As restoration initiatives continue to be implemented, the need for resource allocation for the operational maintenance of these initiatives will become increasingly necessary to ensure their long term success.

  Unless executive and politicians within the City of Toronto continue to embrace the importance and value of restoration and naturalization in Toronto, the allocation of resources supporting restoration efforts may be adversely affected. It would be unfortunate if restoration were to be relegated to the margins of city recognized and funded initiatives, and become vulnerable to cuts from the pressure to reduce or maintain current tax levels.

  We would like to see a formal program for restoration across the New Toronto. Looking even further, we would like to see prairies, Oak savannahs, and wet lands would replace many of the manicured lawns found on public properties and large traffic medians around the City's streets and highways. In order to realize this vision, the necessary skill sets, knowledge and operations practices must be expanded and further developed. Trials will have to be run to determine the success of certain native plantings in response to urban roadside conditions, so as to develop an inventory of plants suitable for these applications. As recognized by U.S. President Clinton in his Executive Order, the use of native plant material not only preserves our heritage, but also overcomes the water, pesticide and nutrient requirements, run-off problems and erosion problems associated with many non native plants. The use of native plants has enough economic

sense to be applied to all federal buildings through the US, and throughout Chicago and other communities. Surely it makes sense to apply in Toronto as well.

- The City's on-going ability to adapt to support community involvement and volunteer groups

  The City needs to re-examine the challenges of working in a dynamic partnership with volunteer organizations. A program such as ours poses new challenges:

  - Resource, planning and support requirements
  - Influence and expectations of volunteer organizations on park and City policy and initiatives
  - The need to reconcile divergent points of view between the organization and staff

  This will require changes to the roles of staff to recognize their work with volunteers and the challenges raised by working side-by-side with them. This is very similar to the philosophy and evolution of roles seen in private industry, with the establishment of cross functional teams.

- Development of a new skill set and infrastructure for restoration and naturalization

  Restoration and naturalization are relatively new disciplines. They bear little relation to traditional gardening, and are seldom practised in landscaping. In order for the City to ensure long term success in restoration and naturalization, it must continue to develop the associated restoration skill sets and native plant knowledge. The biggest threat that we face is lack of knowledge, and the failures associated with improperly applied restoration practices. Awareness, education and sound practices are our biggest allies.

- Integrating regional environmental concepts and practices into education

  Education at the primary, secondary, college and university levels would benefit from the integration of local environmental concepts and practices. Most Canadians have a poor understanding of ecosystems and their importance and impact on our daily lives. This includes the average Canadian's perception and understanding of the importance of restoration and naturalization. A basic understanding is required before environmental and environmentally friendly practices can be embraced on a large scale.

  At the college and university level, while we do see curricula beginning to include ecological restoration, a greater emphasis would contribute much towards the restoration challenges that face both urban and wilderness areas.

- Revising bylaws to differentiate between noxious alien weeds and native plants

  Native plants including Goldenrods, Asters, Milkweeds, and Joe-Pye's are inappropriately recognized as noxious weeds by the Ministry of Agriculture and Food. Purple Loosestrife, Tartarian Honeysuckle, Norway Maples, Japanese Knotweed, Himalayan Balsam, Knapweed and Common St. Johnswort, widely recognized as invasive aliens (noxious weeds), can still be found for sale in nurseries and seed houses around Ontario. Current laws prohibit useful plants and allow problem plants. Clearly one way of reducing the impact of noxious weeds is to ensure that they are properly addressed by existing bylaws, and to end their distribution and sale. The next step is to control their growth. It is estimated that in the U.S., exotic plants are spreading at a rate of 3 million acres of land per year on federal lands. In 1993, the U.S. Congressional Office of Technology Assessment estimated the cost of all invasive alien species at $4.5 to $6.5 billion annually. This has been termed the "Environmental Challenge of the 21st Century", and often referred to as 'biological pollution'.[vii]

The Canadian Biodiversity Strategy (1995) recognizes the need for, "the development and implementation of measures such as policies, plans, legislation, and programs to prevent alien and modified organisms from adversely affecting biodiversity"[viii].

- The proper sourcing of pertinent plant material for reintroduction

  One of the challenges of restoration and naturalization is the sourcing of plant material from the appropriate bioregion. Unless care is taken in the sourcing of seed for plant material, and the re-introduction of plant material to the appropriate bioregion, the integrity and intent of the restoration will be greatly compromised.

- Encouraging homeowners to 'Expand the Boundaries of High Park'

  Public awareness and education are key to the widespread acceptance of restoration and naturalization. An initiative of our Natural Environment sub committee encourages local residents to use native plants as part of homeowner and community landscaping. Third and fourth generation weed laws in the United States encourage this use and in some instances go so far as to require developers to include in their subdivisions 30 metre scenic easements planted with native plants, wildflowers, and grasses between homes and major streets.

- Enhancing the knowledge and skill sets of our volunteers

  One of the limitations that we currently face is widespread native plant knowledge amongst our volunteers. This creates a challenge when we measure the results of our efforts through the application of different monitoring techniques. Plant identification, as well as knowledge of growth requirements (shade tolerance, drought tolerance, etc) is important to our ability to evolve our program. Roughly half a dozen of our volunteers are highly skilled in plant identification (grasses, forbes, trees, wildflowers, etc) and knowledge. Education, informal and possibly formal, will be an area of focus as we move forward.

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INDUSTRIAL LAND RECLAMATION: PARTNERSHIPS BETWEEN INDUSTRY, GOVERNMENT AND ACADEMIA – THE ROLE OF GRADUATE STUDENTS OF LANDSCAPE ARCHITECTURE

Larry B. Harder, Associate Professor
Fiona Rintoul, Adjunct Professor
Denise Hands, Graduate Student

School of Landscape Architecture
University of Guelph

ABSTRACT

The reclamation of industrial lands is one of the great environmental challenges of the new millennium, as society addresses the legacy of its heavy industrial past. This legacy is the result of many factors, including the incremental accumulation of industrial wastes over time, the abandonment of now redundant industrial facilities, and the down-sizing and conversion of on-going industrial activities and industrial sites. Reclamation of industrial lands requires the skills of many disciplines, and the participation of many players. Since 1992, the graduate students of the School of Landscape Architecture at the University of Guelph have been involved annually in course work that focuses on co-operative landscape restoration, rehabilitation and reclamation efforts for a wide variety of sites, including a range of very challenging industrial sites. This paper presents a summary of the experience and contributions that landscape architecture students can provide in advancing efforts to effect industrial reclamation on various industrial sites in the Hamilton Harbour and Niagara Falls areas. The projects represent a diverse range of collaborations between private industry, several types of public agencies, and universities. The conclusions drawn from these experiences are that the benefits and advantages of the participation of landscape architecture students are many, unique, valued and valuable, including, among others, providing practical project experience for the students, promotional value for industry and agencies, and tangible solutions for site restoration, which lead toward on-site implementation and environmental improvement.

Introduction

As the clock winds down on the 20th century, we look ahead to the promise and possibility of a future in which we have both the means and motivation to face the great environmental and social challenges that are before us. As we approach this imagined temporal divide, we may be tempted to sever ourselves from the past, and cast our gaze forward into an optimistic future. The irony, though, is that to look forward we must first look backwards, for it is the past that has left the legacy of challenges that must be met in the new millennium. Nowhere is this more self-evident than when one regards the enormous environmental legacy that we have inherited from our heavy industrial past.

This paper recounts the experience of students of landscape architecture who are making a contribution to address, or perhaps more accurately to redress, some of this legacy. For more than five years, graduate students in the School of Landscape Architecture at the University of Guelph have been making their contributions to the team effort required for industrial land reclamation, as part of course work offered in a master's program. Students have been involved annually in projects that focus on co-operative landscape restoration, rehabilitation and reclamation efforts for a wide variety of sites, including a wide range of industrial sites. This has been an opportunity to explore the role that landscape architecture may contribute to industrial reclamation efforts.

The role of the landscape architecture students will be described by first summarizing the general context of their course work, and then discussing a case study of an on-going industrial land reclamation project for CYTEC Canada's Welland Plant in Niagara Falls, Ontario. In this project, the contributions of landscape architecture students, amongst others, are yielding exciting and very promising results in a collaborative project that brings together industry and academia, working together for environmental improvement. This will be followed by discussion of the benefits of such projects and what has been learned along the way.

Reclamation of Industrial Lands: The Legacy

Centuries of industrialization have left their mark forcefully and indelibly on the global landscape. Our cultures may well have evolved into the post-industrial era, but we still live cheek to jowl with what we have left behind from industrialization This leftover baggage is found in vast and obvious evidence in the mountainous colliery wastes of northern England, the gargantuan slag heaps of Germany's Ruhr Valley, the miles of abandoned steel mills along rivers in the great American Rust Belt, the petro-chemical sludge in the Detroit River, or the incidence of cancer in the Russian Urals. But the relicts are found in smaller and more subtle pieces, too – a toxic fire in a Hamilton, Ontario recycling depot, an abandoned foundry in Guelph, Ontario with soils too toxic for anyone to want to buy the site, post-war radioactive soils in Stouffville, Ontario, leachates from long-decommissioned domestic landfills. We do not have to look far to face our legacy.

We have inherited this legacy in many ways. Most obvious, perhaps, is the simple accumulation of waste by-products of all our many resource extraction and industrial production processes, and energy production and transportation technologies. What we do not want, we cast aside, like the tonnes of ore from which we extract grams of gold. In getting what we want, we make many things that we do not want, like sulphurous smoke from incineration of coal for power. Our legacy is stored in air, water, and soil, like heavy metals settling in harbour sediments or bio-accumulating up the food chain. When demand drops or technology changes, the facilities that become redundant are left abandoned on the landscape – often as problems to solve with no one willing to take the responsibility to solve them. When the economy swings, a product line shifts, production is moved to where the labour is cheaper, or a down-sizing is implemented – the plant closes, the workers leave, and the gates swing closed. Sites are abandoned, ruins remain. A facility -- once an asset – now becomes a liability.

Reclamation of Industrial Lands: The Roles

It is unnecessary, for the readers of this paper, to detail any further the nature of the legacy we have inherited. We are united by a common desire and motivation to address this legacy and do our level best to restore, reclaim, and rehabilitate the industrial landscape to a condition of ecological integrity, function, and health. Undoubtedly, all the readers of this paper are also very well aware that this is a daunting task that takes the skills of many disciplines and the participation of many players. Whether ecologist or engineer, hydrologist or terrestrial biologist, planner or politician, CEO or community activist, there are important niches to fill in the co-operative task of industrial land reclamation. No one discipline has all the skills that are necessary to bring to bear on the problems. The challenges are too great. The conditions are too complex.

One group of players includes landscape architects. As planners, designers, and makers of landscapes, they have a particular tool box of skills that can be applied to the problems of industrial land reclamation. These skills include the ability to analyse site conditions, propose certain kinds of physical design solutions, and manage their implementation. They are particularly adept at giving physical form to ideas.

The Role Of Landscape Architecture Students

Reclamation of Industrial Lands: The Academic Context

The Guelph School of Landscape Architecture is a professional school which offers instruction in landscape architecture at both the undergraduate and graduate levels. The work related in this paper has occurred in or partially as a result of, or with the participation of, a graduate level course in the second year of the three year Master of Landscape Architecture (MLA) program. The course is entitled "Plants and the Environment" and focuses on a combination of planting design and applied ecology, and always involves intensive project work in the design studio in combination with lecture content. The intent of the course, and the entire program for that matter, is to produce professional landscape architects who are informed and aware of the challenges that will face them in the professional world, and to provide them with hands-on experience that will equip them to meet the challenges.

For the last six years, the course has been organized such that the students have undertaken "real" projects for "real" clients in which the role of the students is to provide design and technical services for the community, industry, or government who would not otherwise have the means or the opportunity to acquire landscape architectural services. For the last five years, projects have included numerous industrial reclamation sites, which represent collaboration between the students, their instructors, and a variety of public and industry clients.

The first (non-industrial) restoration project was undertaken in response to a request from The Kleinburg and Area Rate-payers Association, north of Toronto, and involved the conversion of a corn field into a naturalized community forest. Since then the list of clients has included Parks Canada, The Royal Botanical Gardens in Hamilton, the cities of Hamilton and Burlington, the Hamilton Harbour Commission, the Canada Centre ofr Inland Waters, a steel products manufacturer on Hamilton Harbour, Conestoga College in Kitchener, and most recently, the Welland Plant of CYTEC Canada, a chemical manufacturer in the city of Niagara Falls.

These studies represent a diverse sampling of collaboration between academia, government, and industry. A hallmark of each project undertaken to date has been the liaison of the students and their instructors with the client, and often many other players. For the Kleinburg project, the students worked with community members, and organized and presented at public meetings. The Trent-Severn work involved co-ordination with the Parks Canada Regional Office in Cornwall, regional managers of the Trent-Severn Waterway, local lockmasters and maintenance personnel, and the community group the "Friends of the Trent-Severn." Much of the work in the Hamilton Harbour area was facilitated over two years between the many clients by John Hall, co-ordinator of the Hamilton Harbour Fish and Wildlife Restoration Project. The work at Conestoga College involved the College administration as well as the plant operations staff. On-going work at CYTEC Canada involves a collaboration of CYTEC personnel, with faculty from both the University of Guelph and the University of Waterloo.

The range of projects has also been very diverse. Work for Parks Canada involved the preparation of naturalization schemes for four lockstation sites on the Trent-Severn Waterway, each of which was in a different ecological context. Some of the portions of these sites represent what might be thought of as "old" industrial sites, comprised of 90 year-old piles of rock wastes that were the detritus of canal building, and sites that were former 19th century mill or manufacturing centres. Sites in the Hamilton Harbour area ranged from a restoration of oak savanna and natural shoreline to areas of toxic industrial fill. Even the relatively benign campus of Conestoga College featured a pond that is the relict of a former gravel pit operation. The work at CYTEC focuses on large brownfield demolition site, occupying a large portion of an otherwise active chemical plant

Course Organization

The course occurs in the fall semester of the second year, and lasts for one semester. Class size in is the range of 12-15 students, whose backgrounds are very diverse. Their undergraduate education typically includes a balance of degrees from the liberal arts, the environmental sciences, and planning, with a smattering of fine arts, business, education, undergraduate landscape architecture and other degrees, including the occasional PhD. The students are cultural diverse as well, and have included students from all parts of Canada, the United States, mainland China, Taiwan, and Russia. The students are typically older, the age ranging from the mid 20s to the late 50s, although the majority are in their mid to late 20s, with a balance of males and females. Many have extensive work experience of many types, including technical, educational, professional and business occupations.

The studio portion of the course is organized very much like a consulting office. Students are organized into groups to accomplish the tasks that need to be done, while the primary instructor, Larry Harder, acts as an advisor for the essentially self-directed teams. The instructor searches out and sets up the project, initiates the initial client contact, tends to the essential administration and organization that is required, and then sets up the client /consultant relationship between the client and the students.

The criteria for project selection are that the project must emphasize the restoration or rehabilitation of "natural systems" with an emphasis on plants and habitat creation (no major structures or civil engineering, for example), it must be large enough to be able to consider the problem at a variety of scales, it must be diverse enough to offer a variety of challenges and potential solutions, and it must have a community service or environmental improvement objective.

There must also be a willing and participatory client. In securing projects, it has been the practise to ask the client for commitment of financial support, as a measure of commitment to the process. The funding, which has varied in the range of $2000 to $8,500 per semester, is used to offset students' out-of-pocket expenses, travel and accommodation costs, and production costs for the deliverables given to the client, as well as copies for school records. Clients are asked, too, to provide a designated liaison for the project, to offer whatever technical assistance or background data that may be available, and to be present at and provide feedback to the students at presentations of the work

There are high expectations of the students as well. It helps that they are usually highly motivated by the difficult problems they are asked to address. They are expected to treat the project seriously and approach their work with a high level of professionalism. They appreciate and respond to the financial support of the client, and are expected to manage their expenses in a fiscally responsible manner (with oversight by their instructor). They are also expected to deal with their client according to all the accepted rules of client contact, including client confidentiality. They are expected to be organized and thorough. In short, they are expected to treat the project as a real consulting job.

Projects typically involve three phases, each of which is characterized by deliverables that are provided to the client(s).

The first phase is a background phase, in which the students are required to acquire and analyse background data, to determine or clarify the project terms of reference, to investigate the site, to establish client rapport, and to report their findings. This is typically accomplished as a class-wide effort, usually kicked off by an initial client meeting and site visit. This phase culminates in a formal, professionally organized background report which is provided to the client.

The second phase is a "masterplanning phase" which is usually done in groups of three or four. The objective of this phase is to propose a physical design solution for the site(s) with information that suggests how it might be implemented. The product of this phase is a set of alternative physical plans for the restoration, rehabilitation, or reclamation of an entire site, typically at scales between 1:1000 and 1:5000. Sometimes this means three or for different masterplans for one site, as in the case of Conestoga College and CYTEC Canada. Other times this may mean plans for a diversity of sites in the same area, as has been the case for our work for the Trent-Severn and Hamilton Harbour. The deliverables for this phase include physical plans, as well as written design briefs and a management plan. This phase is usually completed by a formal presentation to the client, with invited guests who may be professionals, community members, corporate executives, or any combination of others.

The last phase is a more detailed design phase. Students individually select a detailed portion of the masterplann site to develop into more detail, at a variety of scales between 1:1000 and 1:200. Students are allowed the option of doing a detailed physical plan or a detailed management plan. Most choose to do a detailed physical plan. The tangible products of this final phase are 12-16 detailed layout and conceptual planting plans/management plans for portions of the overall site.

The client is given full-size black-and-white prints of all the plan drawings, copies of any reports, and usually a set of colour slides. Colour slides have proven to be an economical way to provide the client with a portable, useable, and adaptable record of the work, while the students can then retain the original colour drawings for their professional portfolios. The conclusions of the last phase depend on circumstances, and also may end in another presentation, or sometimes in an open house or exhibition of drawings, preferably at the client's location. In any case, client representatives and most often also other invited participants are asked to view and comment on the student work.

Range of Sites: Range of Challenges

The range of sites that the students have been asked to address have been very wide, the challenges very great, and many of the solutions very innovative. Some of the restoration challenges are very gentle and the sites almost pristine. One proposal for restoration in the Hamilton Harbour area addressed the restoration of oak savanna in a virtually undisturbed site adjacent to Cootes Paradise (the site of a major on-going wetland restoration managed by the Royal Botanical Gardens) in which the rehabilitation issues dealt with biodiversity the subtleties of ecosystem change over time, the effects of the long-term suppression of fire, the selective removal of competitive species, and recommended spacing of forest thinning to achieve the necessary light intensities for savanna species. At the same time, at the other end of the same Hamilton Harbour, another group was given the challenge of determining what to do, in terms of shoreline and backshore habitat creation, with a shoreline property which was mostly an asphalt parking lot covering a site comprised of gravel fill over top a glacial beach bar. The site was located underneath the Burlington Skyway Bridge of the Queen Elizabeth Way expressway, at the entrance to the Burlington Ship Canal (the entrance to Hamilton Harbour), in which the main shoreline dynamic was the irregular two metre displacement of water at the shoreline edge as large ships passed through the canal.

Many sites have involved shoreline or aquatic conditions. Students have contributed to the on-going restoration efforts for Cootes Paradise, which is one of the largest freshwater wetland restorations ever undertaken in North America. One of many challenges here is how to undertake a wetland restoration in which the hydrological cycles are opposite to natural wetland cycles: Cootes Paradise is linked to Lake Ontario, the water level of which is maintained for navigation and power generation at Cornwall at a level which is highest in late summer and fall, which is opposite to the late summer and fall draw-down which normally occurs in temperate wetlands. Another

Hamilton Harbour site concerned shoreline naturalization ideas for Hamilton's West Harbourfront area, currently occupied by rail lines and rail yards on fill. One of the more challenging sites was the linkage between Hamilton Harbour and Cootes Paradise, through the historic Desjardins Canal, which runs underneath a main CNR rail line, a GO Train commuter rail line, York Boulevard (a major arterial road), Highway 403 (an expressway), and a major transmission line – all in a couple of hundred metres.

Project sites have also included stream restorations, bank stabilizations, and fish and wildlife habitat recreations. All of these projects have their challenges, which face the students with hard decisions. The realization came to one group working in the Windermere Basin of Hamilton Harbour, an area with heavily polluted bottom sediments, that by installing a biologically diverse wetland re-creation, they would be inviting waterfowl to die, by providing them with a diet of heavy metals, phenols, and other contaminants taken up by the plants. It was discovered on the actively used site of the steel product manufacturer that the "soils" consisted of 2 metres of highly alkaline blast furnace slag, on top 2 metres of domestic landfill, which overlay an indeterminate depth of organic mucks, the deeply buried remnant of the pre-development shoreline marshes of the site. Even at the relatively benign and apparently pastoral site of Conestoga College, the soil conditions were found to consist of a thin layer of imported topsoil spread over a post-extraction substrate of almost pure gravel, with drainage too rapid and fertility too low for many woody plant species.

The challenges faced by the students have not been limited to the physical qualities of the sites. Some of the work in Hamilton Harbour done for the city proposed plans for property actually in disputed jurisdiction with the Hamilton Harbour Commissioners. Harbour work that involved fish habitat structures, was criticized by the boating community for reducing even further the navigable recreational area of the harbour. It came as a surprise to many students that any shoreline rehabilitation activities in Hamilton Harbour came under the terms of the Federal Navigation Act, including the now non-navigable Cootes Paradise. For the steel products manufacturer's site, all major meetings and presentations had to be attended by representatives of both management and the union. One group dealing with a naturalization of a Trent-Severn lockstation had to wrestle with the very real problem of a site maintenance supervisor who had been on the job for nearly forty years, whose image of proper site management did not correspond with the students' (or Parks Canada's) objectives for naturalization. The students' pragmatic proposal for a solution: wait until he retires.

Response of Clients

The client collaborators have almost always been overwhelmed by the results of the students' efforts in the Plants and Environment course. They are briefed at the outset of the process on what to expect, in terms of the deliverables, but usually do not expect the depth or the quality of the product that they receive. They are particularly impressed at the outset by the students' graphic products, in the form of plans, sketches, sections, and report graphics, which are particular skills that landscape architects bring to communication. They are also impressed by the students' verbal presentation skills.

There is always debate about the details of the solutions themselves, but most of the time the criticism is not negative, but more often than not is simply informed by the clients' greater familiarity with the context and the difficulties, which range from the physical to the financial, political and administrative.

Perhaps the most common general reaction is that the client is given the opportunity to see their problem or their site in ways that they had not necessarily previously considered. They begin to see the possibilities that have been given form by the students. The following case study gives some indication of what a motivated client is prepared

to do with the possibilities. In this case, landscape architecture students entered into a process that had already been initiated.

CYTEC Canada Welland Plant: A Case Study

Background to the CYTEC Study

In the fall of 1996 representatives from the Universities of Waterloo and Guelph were invited to the Canadian Corporate Headquarters of CYTEC Canada, a chemical producer, at their Welland Plant in Niagara Falls, Ontario to discuss the potential for restoration, rehabilitation and reclamation of portions of the site which are no longer in active industrial use. The purpose of the project was to develop strategies and plans for landscape, aesthetic, and environmental improvements for the Welland Plant property, which in total is in the order of 405 hectares (1000 acres), comprised of an active chemical production facility, administrative buildings, active and decommissioned settling ponds, and a large demolition area. The operating plant currently consists of an administration cluster and a production plant which together, though physically separated, occupy only a very small portion of the site.

The circumstances that initiated this meeting had been developing over a number of years as CYTEC found itself evolving its product line and in response to that, its physical plant as well. The facility had begun in the war years as an ammunition factory, had converted to fertilizer production in the post-war period, and is currently producing phosphine gases and phosphine products. The result of this corporate evolution was a large inventory of decommissioned buildings and infrastructure systems. Demolition of these facilities began in the 1980s such that by the end of the 90s an area equivalent in size to perhaps twelve city blocks had been razed to the ground. It was presumed that many physical and chemical remnants of all of these enterprises were present to some degree on the property when the universities first evaluated the site back in 1996.

The Details of the Collaboration

Since removal of buildings and infrastructure was a major component of the facility's evolution in the 1990s, a great opportunity was provided for an alternative land use -- particularly one involving a landscape component that responded to industrial conditions yet linked to existing plant communities and ecosystems both on and off site. Both institutions immediately recognized the tremendous opportunity the site held for industrial rehabilitation and restoration, and the value of housing the project within a multi-disciplinary academic setting. Both institutions were aware that the skills and knowledge that would be required for this task demanded their collaboration.

Initiated by the client, and based on a desire to enhance their corporate headquarters not only aesthetically, but ecologically, this undertaking is a substantial commitment.

While members of the chemical industry are often reluctant to open their doors to potential outside scrutiny, in this case, both universities were invited to investigate the site's potential prior to initiating any physical rehabilitation work. The work has been co-ordinated from the CYTEC side by employee Brain Schram, with the participation of a number of others including Dave Cole, George Slayney, Doug Roy, and Plant Manager Tony Mueller. Since the client has been receptive to the advice of the Project Team and has been open to experimentation, the potential for the project to be an evolving site for current restoration research is immense.

Through 1997 the site was evaluated in three distinct phases. The First Phase was undertaken by planning students at the University of Waterloo School of Urban and Regional Planning, directed by Roger Suffling. In Phase 2 students enrolled a Waterloo Environmental Studies field course, and instructed by Larry Lamb, generated preliminary base data on soils, water, vegetation, and wildlife before handing off the project in the fall of 1997 for Phase 3 to design students at the Guelph School of Landscape Architecture, who were instructed by Larry Harder and Fiona Rintoul. Greg Michelenko and Steve Murphy from Waterloo also participated in various capacities in the first two phases. A separate visual analysis had also been completed as a summer project by Fiona Rintoul, with the assistance of landscape architecture student John Lewis.

The net result of this year-long investigation was the generation of several masterplan strategies which pointed to the need for a much more rigorous and detailed design and implementation phase, now underway through 1998. A commitment was made that 1998 was to be the first year of a five year collaborative involvement between CTYEC and the two universities, involving at least three distinct faculties, with the additional involvement as required of professional consultants and contractors.

The On-going Work

To initiate the implementation phase, the Guelph and Waterloo professionals who had been involved in the previous phase of the study met with CYTEC personnel and after careful re-examination of the masterplans produced by the landscape architecture students in the Fall of 1997, came up with a working concept plan, which was to be elaborated as the implementation proceeded.

To get the project into the ground, a summer student employment project was created. Four students were hired, including Denise Hands, one of the graduate students from Guelph who had worked on the project in Fall of 1997, Heather Whitehouse, an undergraduate biology student from Waterloo, and two labourers. The students were hired as employees of CYTEC, but for the purposes of the work to be done for the project, were supervised by their university instructors, who were in turn hired as private consultants to oversee the project (within the framework of accepted administrative arrangements with their institutions). As well, another Waterloo student, Jason Whitfield, concurrently undertook soil studies on site as an undergraduate thesis topic. This group constituted the on-site project team. Denise Hands was given responsibility of on-site project co-ordination.

While 1997 involved very selective visits to the site, in the summer of 1998 students, faculty, and CYTEC employees were working together on a daily basis, generating more detailed base information, mapping physical conditions and modifying the design concept to reflect those findings. At the same time, initial plant community installation was taking place in areas where conditions were most receptive. As this is written, both native prairie and meadow communities had been established, while conditions for forest, carr, wetland, scree, and alvar communities were still being verified. A number of bird nesting boxes and perching poles have been installed. A monitoring program has also been set up to monitor the success of these and other planted areas. An experimental alvar habitat area has been designed for summer construction and fall planting. A node of slough forest has also been designeted for planting in the Fall of 1998 in proximity to the main administration buildings. Several small woody nodes of "scree forest" at the main entrance to the plant and at major intersections were also planned for Fall implementation.

A great deal of time was devoted in the summer of 1998 to searching out, verifying and synthesizing information concerning existing conditions. This work was done primarily by students in a number of disciplines, including landscape architecture, biology, and environmental science. Background research has included a detailed inventory of existing plant communities and associated site conditions, the monitoring of hydrological conditions

such as standing water, level of the water table, and toxicity levels of surface and subsurface water; as well as the monitoring of subsurface conditions such as locations of buried foundations, basements and other demolished structures, remaining infrastructure, soil compaction, toxicity and composition.

All of the above background research is being used to inform the design process as it proceeds and is being amalgamated into the comprehensive masterplan and a proposed overall management plan.. Modifications and additions to the masterplan are being made on an on-going basis as more details are learned about existing conditions, limitations and opportunities.

This work required that students had open access, not only to the site and the conditions found there, but also to corporate reports, base maps and the experiences of current employees.

The Scope of the Project: Some of the Details

CYTEC's long production history involving a range of different chemical processes in various locations around the site, has resulted in a myriad of combinations and subtle gradations in current site conditions. Some of the remnants of industrial production on the site include: surface deposits of cinder and gravel of various depths, soil compaction, as well as varying levels of nitrate, ammonia and phosphate contamination in the soil. Many buildings have been leveled to ground, but their foundations, basements and infrastructure generally remain and have been back-filled with construction debris. Roads and rail lines have been removed. Thus a patchwork of perched water tables and varying soil and drainage conditions has been created. The one aspect of the site that is relatively constant throughout is topography. The main demolition area, which is the focus of work for 1998, is relatively flat with most of the topographic variation occurring at the north and south perimeters where two water courses, Thompson's Creek and Chippawa Creek, respectively, cross the site.

The physical complexity of the site adds complexity to the design process. However it also lends itself to the development and enhancement of a variety of habitat communities. A concerted effort has been made to match appropriate habitat communities with current conditions in order to minimize costly and time-consuming amelioration and increase survival rates. For example, many of the concrete pads which remain on the site will be used to develop pavement alvar communities emulating local limestone alvars on the nearby Niagara Escarpment. There are plans to use piles of concrete rubble from demolished pads as well, in conjunction with the alvars and to create snake habitat. Extensive monitoring of existing plant communities and their associated site conditions is also being conducted on an on-going basis in order to develop models for appropriate post-industrial vegetative communities. Other proposed habitat communities for the Welland site include: open grassland, meadow, prairie, wet meadow, shrub thicket and carr communities, a wetland complex, slough forest, upland Carolinian forest, early successional forest, forest edge and riparian communities. The grassland communities will dominate the central portion of the site where the maintenance of clear views from the administration area to the production area is a priority. In the perimeter areas of the site, taller plantings such as the forest communities will be developed. Slough forest is a dominant community in the undisturbed areas of the surrounding region supporting a number of provincially rare species, and thus will be a priority community for restoration.

Because of the complicated nature of the site, as well as the number and variety of different parties involved, the CYTEC Canada Welland Plant Rehabilitation Project has necessarily been a balancing process from the beginning. Short term goals need to be balanced with long term plans. Likewise, the goals and motivations of the various parties involved need to be in equilibrium. In this instance, for example, design and implementation work is the primary responsibility of Guelph, while data inventory and monitoring are spear-headed by Waterloo, with major logistics, equipment use and so on co-ordinated by CYTEC. The wish to create an immediate effect and

make significant progress must be offset by the very real need to continue gathering further background data in order to make informed decisions. Similarly, what is currently being implemented must be integrated into the structure of the long term management and design goals, without being haphazard or restricting flexibility. From a practical standpoint, the desire to restore the site to its original habitat communities must be tempered by the harsh present realities of the site and its capabilities. Likewise, visual effect must be balanced by cost effectiveness. Survival of plant material must be weighed against reasonable maintenance time and costs, as well as ecological diversity. Some diversity will have to be sacrificed since the present site conditions preclude many species that cannot withstand the harsh environment without high levels of amelioration and care.

The Specific Role of Landscape Architecture Graduate Students

The complexity of the project means that there are a significant number of areas where specific expertise and/or background research is needed. This provides an excellent opportunity for graduate students in landscape architecture to become involved in the project. Because landscape architecture graduate students generally come from a wide variety of educational backgrounds, they have a very broad range of expertise to offer as well as advanced research skills. Thus far in the CYTEC project, landscape architecture graduate students have been involved in the preliminary design phase (developing innovative and comprehensive plans for the overall site); in the research phase (researching specific aspects of the site such as the feasibility and techniques for establishing alvar communities, and/or techniques for ameliorating various site conditions); and in the implementation phase (masterplan design, installation, developing promotional graphic material and evolving detailed planting and management plans for a number of distinct areas of the site). This is all undertaken, of course, under the guidance of their instructors, in their context as academic consultants.

Involving graduate students in the project is an important way for CYTEC to reduce costs and is a very appropriate "grassroots" approach for this type of project. Given the large scale of the site, such a project might be cost-prohibitive otherwise. As a hired summer intern, for example, a graduate student can be on site on a daily basis easing the collection of data and allowing for regular monitoring. Site presence also increases the profile of the project amongst plant employees, and thus increases their interest and sense of ownership for the rehabilitation. In general, the range of different parties involved in this project has allowed for a number of promotional opportunities through academic publications, as well as educational opportunities.

A number of students from both institutions are using this site as the location for both undergraduate and graduate thesis work, while many other students will be gaining valuable restoration/rehabilitation experience either as part of their course work or through employment opportunities created by the project. An initial planting day, for example, involved a number of additional students from both institutions, and some CTYEC staff and executives, as well. The site has been, and will continue to be used for study field trips to observe and participate in the work in progress.

What are the Benefits of Collaboration?

The Benefits for the Client Collaborators

The main advantage achieved by the client in these collaborative projects is the generation of ideas and alternatives in a way that is non-threatening, non-committal and cost-effective. They are able to take advantage of the wide range of perspectives, insight, and experience of the students (and their experienced instructors), and incorporate the ideas and enthusiasm generated to the advancement of their own objectives. Sometimes they get ideas about what to do, other times, how it might be done.

The benefits that accrue to the client collaborators in this process range from the tangible products that are provided in terms of plans, sketches, and reports, to a variety of broader and perhaps fundamentally more important intangibles. In these studies the students take on the role of consultants (supervised by their instructors) to provide a design service meant primarily to generate ideas for the client in a situation that ultimately leads to some sort of real-life implementation, although not necessarily by the students or according to their exact specifications.

Perhaps one of the greatest benefits is that the students bring an openness to the possibilities. They have the ability to provide a free and fresh response to problems and solutions, which is driven in part from not being a "part of the system" and in part through a combination of enthusiasm, idealism, naivete, persistence, and even arrogance that is not afraid to be challenging. They are also not jaded by the blinders of "practicality," (which can be both good and bad). This all allows them to "push the envelop" and open up options that may not have previously been considered.

Through the experience of interacting with the students, and particularly as a result of presentations, the clients are often put in touch with others who may be able to shed additional light on their problem, or provide insight into solutions. Sometimes the greatest benefit is simply getting people from the same organization talking to one another. That certainly was the case with the Trent-Severn project, in which important communication was established between national, regional and local components of Parks Canada, just by getting many players into the same room at the same time to review the student work.

Sometimes the benefit arises from the networking that happens between participants. The student work for Hamilton Harbour over a two year period brought many stakeholders in the region of Hamilton Harbour into the same room, several times, including municipalities, private industry, and other environmental agencies like the Royal Botanical Gardens and the Canada Centre for Inland Waters.

Sometimes the benefits may be the introduction of clients to other professional or technical people who can further address a particular aspect of a problem, or provide additional insight. At open houses ecologists have been observed talking to corporate managers, engineers talking to biologists, maintenance personnel talking to landscape architects.

The student work may also provide an important political role, especially if there is controversy involved. The students are seen to be "neutral" and perhaps somewhat naive (although given some of the experience of the students this is far from the reality). Because they are not part of the institutional or corporate "system," nor are they professional consultants who may not wish to offend their client, they are therefore given a lot of latitude in the way they analyse a problem and propose solutions. This means that they can raise issues and controversies that it would be "politically incorrect" to do, say within an agency, or between agencies. For example, in some of the work in Cootes Paradise, the students were able to challenge some of the assumptions of the approaches to wetland restoration that were at the time apparently failing. They were able to raise the issue of an outside employee amenity area for the steel products manufacturer, which was side issue in a potentially festering labour dispute. For CYTEC Canada, the students persisted in making recommendations for relocation of a perimeter fence, for improved corporate signage, and for an employee amenity area, which were not central to the terms of reference of the project, but the desirability of which has now been established.

The student work, therefore, becomes a "gentle" or perhaps even "safe" way to promote certain ideas or concepts. Indeed, for some of the work for Hamilton Harbour, that was a deliberate intention – in a way to "shake up" some ideas, and motivate action amongst the diverse stake-holders.

The other side of this is the opportunity to deliberately use the students' work to advance a particular agenda. The option to use the students' work for publicity, internal to an organization or within the large community has great potential. For the steel products manufacturer, a presentation of proposals was used to try to generate employee support for the idea of site improvements. The students' ideas for a trail along railway lands in Hamilton's West Harbourfront urban development area were used as preliminary proposals as part of a major urban development scheme. CYTEC Canada has used samples of the students' ideas to promote its efforts in rehabilitation at a Chemical Producers' Conference.

The Benefits for the Student Collaborators

These projects provide the students with exposure to the issues, knowledge and practices of landscape restoration, rehabilitation and reclamation. They gain some practical experience, and learn about the diversity of the problems and the potential solutions. The student collaborators are highly motivated by the fact that they are working on a "real" project, that there is potential that the work they do may find some form of implementation after they have completed their work, or, in other words, what they do might actually mean something!

These studies provide a wonderful opportunity for the attainment of the academic objectives of the landscape architecture program, which balance the acquisition of the requiset knowledge base and skills sets of landscape architecture with the ideals and attitudes of professionalism. The graduate students are able to bring their academic skills and past academic and work experience to bear very quickly to learn much about site analysis, ecology, plant materials, design, and landscape management, and do an amazing job of acquiring high level skills in plan and report graphics, report writing, and verbal presentations.

Furthermore, these studies provide an introduction to and a forum for the discussion of many issues, not all of which are environmental. There is always spirited debate on the assumptions of naturalization, and the use of native plant materials or the relevance or effectiveness of particular restoration techniques. But discussion also expands to the tough broad issues of resource use conflicts, or definitions of environmental health, or political debates over such issues as jobs *versus* the environment. There is frequent discussion about roles and responsibilities of the many players. Some of the discussion challenges the students' stereo-types and assumptions, by putting them in the difficult position of making compromises and tough decisions for themselves, rather than being passive critics.

One of the main benefits to students is that they get practical experience in both design and project management They are involved in activities that can be directly observed and evaluated. The students thus gain an exposure to the issues of being a professional consultant. They learn many practical lessons about running a consulting project. They usually must respond to a client's terms of reference, and establish a working consultant/client relationship. They are given the opportunity for client contact, and must learn how to read some of the motivations and agenda of the players, and the ways in which they must interact with them. They learn about meeting dynamics and hidden agendas, for example. They are also exposed to the budget and financial aspects of a large project. .

A lesson that is sometimes learned with difficulty has to do with the ability to work together in teams. Because of the amount of work they are asked to do, the relatively short time frame, and the realization that no one individual

can have the knowledge base or the skill sets that are required to accomplish the objectives of the project, they are required to work together to meet their objectives. This requires the development of organizational, co-operative, and dispute resolution skills that are sometimes hard-won.

It also becomes very clear to the students early on that the task of industrial land reclamation is one that demands the skill and co-operation of a variety of players and professions, and that in the big picture, too, no one group has all the skills that are necessary for the successful implementation of a project. They are often exposed to and required to enter into liaisons with other professions. In the case of CYTEC, co-operation has expanded to include students in other disciplines from the University of Waterloo.

The students are also given a directed opportunity to exercise their creativity, and to get feedback that extends beyond the walls of the classroom, from their clients, invited guests, community members, and professionals in a variety of disciplines who are invited to presentations or who otherwise participate in the projects as contacts, advisors, or reviewers of the students' work.

And the students learn a lot from each other. The mutually benefit from the various skills and backgrounds that they each bring to the project work. They also learn a great deal from observing the range of alternative solutions that are innovated by their classmates, in a way that goes far beyond the limitations of their own project focus. They particularly learn from the contrast between sites and between solutions.

The Benefits for the School of Landscape Architecture

The School of Landscape Architecture is a beneficiary of these studies too. Certainly, these studies provide the opportunity to meet academic requirements in an involving, hands-on way – putting into action the ideals of participatory education, learning by doing. However the school also benefits financially, from the dollar support provided to assist the students and the School. The School is able to participate in the wider community, giving something back by providing a community or environmental service. Reciprocally, it gives the School some profile amongst the community, industry, and government. It also promotes the skills and talents of the School's students, some of whom are given employment opportunities either directly or indirectly as a result of the project or exposure to a hiring agency, which in turn helps to establish a good reputation for the School and its graduates. And, of course, the instructors gain experience themselves, extend their contact networks, and gain recognition for the work accomplished.

The Benefits for the Profession of Landscape Architecture

These studies also provide exposure to clients and the community for the profession of landscape architecture. Perhaps the most gratifying comment for a landscape architect or landscape architecture student is the comment often heard at student presentations that "I didn't know that landscape architects could do that!" Landscape architects often feel misunderstood and underappreciated, and such studies as these allow for the promotion of the particular skills that this profession can bring to bear in restoration, rehabilitation or reclamation projects. These skills particularly have to do with design, the visualization of design concepts, implementation of schemes, and landscape management. The studies validate the important role of landscape architects in the multi-disciplinary environment in which these kind of studies must occur and foster an appreciation for collaboration with other participants who have different skills and contributions.

The Benefits for the Environment and the Cause of Industrial and Reclamation

Certainly, the underlying motivation for all this work is ultimately to effect some kind betterment of the environment. The point is to improve water quality, to restore the integrity of ecological systems, to make new habitat, or to promote native species. This is, of course, fundamental to the assumptions of the profession of landscape architecture and landscape architectural education. This is simply one means for achieving these objectives.

Beyond the parochial self-interests of the various participants in this process, there are real benefits to the environment that do result from this activity. Some of these benefits are very tangible – that is the creation of new habitat, or improved aesthetics, or shoreline stabilization. And while the in-ground solutions may not look exactly as the students originally designed them, the students' activities and energies do often motivate a physical response – real environmental improvement.

Some of the benefits, however are more intangible, and have to do with the promotion of social attitudes that promote awareness of natural systems and the mind set that fosters environmental improvement. The work opens up to the clients an awareness of the options and opportunities which lead to the motivation to effect positive change. For some of our clients, the idea of "naturalization" is a new concept, especially in an institutional setting with traditional practices of grounds maintenance. Certainly this was the case for the work on the Trent-Severn and Conestoga College, and the City of Burlington. The bio-engineering options for stream bank rehabilitation, shore stabilization, and slope stabilization became real options for a number of our Hamilton Harbour clients. The students' work has opened up internal institutional discussions about ecological integrity, and bio-diversity, and the use of native plant species and local genetic material, and issues of wildlife management, and control of invasive species, and on and on.

These issues and debates are thus injected into the corporate or institutional or community culture of the clients, all of whom have some measure of responsibility for landscape management. So in various ways, the concepts eventually work themselves out into the environment, perhaps incrementally, perhaps slowly, but always inexorably, resulting in shifts toward environmental improvement. The response may be as simple as the installation of bird boxes, as fundamental as not cutting the grass any more, or as complex as a comprehensive restoration masterplan

Problems

These studies are not without their problems and frustrations.

One of the major limitations simply is time. Within the frameowrk of a course, projects have to be completed in the very short time frame of a single semester, in which the same course has other objectives too, and during which the students concurrently take other demanding courses. This often means that it is not possible to do the depth of research that would be desirable, or to explore as many options as would be optimal, or to achieve a more precise level of detail. It is actually quite astounding what the students are capable of achieving within these limitations.

One of the initial difficulties sometimes has to do with attitudes. Sometimes the students come to a difficult reclamation problem with environmental prejudices. It is not uncommon for students to be biassed by a kind of pure idealistic environmentalism, which at one end of the scale says that if we have an apparently pristine environmental condition we should not touch it, and at the other expresses deep disgust at the extent to which we

have defiled the landscape. It is also not unusual for the students to bring to the table deeply held negative stereotypes of industry. On the opposite site, the clients sometime harbour a great deal of suspicion of the students' attitudes and agendas, and concern for their lack of practicality. There is also in industry a sometimes not-so-subtle distrust of academia. These attitudes need to be overcome in order to establish the proper rapport required to undertake a project. However, this generally happens quite quickly as the students grow into their role as consultants working on behalf of the objectives of the client and the client becomes comfortable that the students are responding to their objectives.

There can be a myriad of logistical and operational problems. For example, the schedule of the client has to be adaptable enough to dovetail with the calendar of the academic semester. Arrangements need to be made for meetings and site visits that usually have to fall within assigned class times, because the students, of course, have other academic obligations. In order to be reimbursed for expenses from the project budget, students have to be diligent in keeping records and receipts, which for some is a new set of skills. Some sites provide problems of access. One Hamilton Harbour site, for example, could only be accessed across a CNR Rail line, unauthorized crossing of which contravenes federal law. Other sites lie behind fences and closed gates, and require security authorization to enter. The nature of some reclamation sites raises issues of liability and safety. (The university carries liability insurance for students on authorized filed trips.) Some sites require the use of hardhats and safety boots. It is difficult to manage studies at sites distant from Guelph, which compromises a students' ability to easily return to the site for further study.

There are always data problems too. Getting base maps is often a challenge. It is even a bigger challenge to get base maps of an appropriate scale that are current and to a sufficient level of accuracy. The availability, quality, and consistency of background data is often quite poor. There is usually a dearth of important information regarding such things as topography, soils, hydrology, site history, infrastructure, and so on, all of which compromise the quality of the end product, and which have to be dealt with rather more abstractly and intuitively than would be the ideal.

There is also a lack of easily accessible technical and scientific background data to inform the process. While the students are quite adept at turning up relevant research data, technical information, and precedents, there is never enough time to do systematic research or to methodically integrate what is found into the design process.

One further limitation is that while the nature of the problems the students tackle is very complex, it is not generally possible to make available or to learn all the disciplines that are required to successfully solve a problem. The students are not able to learn very much about successional dynamics, or slope engineering, or hydrology, or shoreline dynamics, or the chemistry of contaminated soils, for example. They do learn, however, how important these things are, and how much reliance is necessary on allied professions in such complex projects.

The time limitation also imposes practical limits on what can be accomplished in the production, quantity and quality of drawings and reports, although the clients are always quite impressed with what they see.

Another issue that has come up has to do with perceived competition with practitioners in the private sector – that is, whether the student projects compete with and undercut professional consultants. The reality is that because of budget limitations, this work is not likely to be undertaken by professionals at the typical stage at which the students are brought in. The scope of work is often quite undefined and quite broad, and would certainly not be practical or economical for a consulting office. Essentially there is no money in it. On the other hand, the further development of the work is an opportunity for professional involvement, which has indeed

occurred in a number of instances. The School of Landscape Architecture is quite aware of this issue, as is the Ontario Association of Landscape Architects, the professional organization representing landscape architects in Ontario. It is the contention of the School that student involvement in such projects meets a community need, and actually promotes the skills of landscape architects in the greater community, which ultimately leads to improved consulting opportunities.

Summary

What Have We Learned along the Way about Industrial Land Reclamation?

So, what have we learned about restoration, rehabilitation, and reclamation as a consequence of the experience accumulated along the way in undertaking these student studies?

First of all , we have learned that when it comes to industrial land reclamation in particular, the problem is immensely diverse and complex. One of the most important lessons is that each and every situation is unique. The complexities of site conditions, site history, on-going ecological processes, the state and extent of disturbance, and the objectives of reclamation are always different, and always site specific. This, of course, makes it difficult to project a solution for one site to another. Each project is an experiment.

Another important lesson is that models of natural systems are not necessarily the appropriate models for restoration and reclamation sites. What model can adequately replicate heavily and continually human modified conditions like the artificially high water levels on the Great Lakes, or the erratic displacement wake of ships passing through a canal, or the alternating alkaline and acid substrata of a filled industrial site?

We have learned that the use of native plant materials can be very difficult to achieve on heavily disturbed industrial sites. This precipitates a debate on the appropriateness of always using native plants which can pit pragmatists against purists. As one project reviewer said, "Why use native plants when you don't even have native soils?"

We have learned that there is little understanding of long-term successional processes on various kinds of industrial lands, but we strongly suspect that they do not always follow ideas of how things are supposed to work according to our current modeling, which, once again, is most frequently derived from the baseline processes operant in "natural" systems.

We have learned that while there is a lot of information of a theoretical, research, technical, and experiential nature available on the restoration of certain "ideal" habitats, like prairies or Carolinian forests, or wetlands, there is precious little available on the design and creation of specialized habitats, like slough forests, wet meadows, or alvars. Most of the data available for forest restoration, for example, relates to deciduous or mixed forests. There is little data on how to design boreal forests, with ecological imperatives in mind, rather than the commercial objectives of forestry. On the other hand, commercial forestry planting techniques may have much to offer in terms of establishing large areas of naturalized forest too.

We have learned that while there seems to be a lot of work going on in this area, there is not a whole lot that has been published and is readily available. Published precedents are hard to come by, although we know that there is a richness of experience which resides in individuals in consultancies and agencies. We have also become aware that some of this information is suppressed for proprietary competitive advantage, or for because of interdisciplinary rivalry.

We have learned that landscape management is very important. It takes time to make a forest or a wetland, and this demands on-going involvement in the landscape. The job is not done after the design is finished and installed. A long-term commitment is required to get the landscape going, and to keep it the way it is intended. The weeds need to be suppressed. The prairie needs to be burned or mowed. The forest needs to be thinned. This all takes commitment of time, resources, and expertise.

Perhaps the most important lesson is to expect the unexpected. While this is likely universally true for any habitat restoration or landscape design project, it is especially true for industrial land reclamation, in which it is impossible to predict what one may encounter. There are few reliable rules, and always lots of surprises.

Where the Work Leads

While the work undertaken within the framework of the Plants and Environment class itself only lasts as long as the Fall semester of the academic year, the seeds planted sometimes do germinate, and the ideas take on a life of their own. This happens in a variety of ways, as the CYTEC case study illustrates.

The main objective of the exercise for the client collaborators is the injection of ideas for the real problems for which they are looking for solutions. And while the precise physical solutions proposed by the students may or may not be appropriate or practical, their concepts are often embraced and enhanced or re-worked in such a way that is compatible with the clients' objectives and mandates. Parks Canada carefully reviewed the work for the Trent-Severn Waterway, which was used by the Cornwall Regional Office to promote to the ideas of naturalization for lockstation sites to the Regional Waterway managers and lockstation management and maintenance personnel. Students were hired (although not necessarily students who had been in the course) to work in the Cornwall office to further develop implementable naturalization plans for a number of lockstation sites.

In the Hamilton Harbour area, the students' work contributed to a growing body of naturalization and reclamation work occurring in the area. A number of the sites worked on by the students were deliberately selected to illustrate what further kind of work might be done. Much of the early work in Cootes Paradise and Hamilton Harbour itself (prior to student involvement) was focussed on wetland restoration or aquatic habitat creation. A number of the student projects were selected to illustrate the need also to address the possibilities for upland terrestrial habitat restoration and stream restoration back from the shoreline. Others were selected to point to the need to tackle the tough sites on the industrial side of the Harbour, extending thinking beyond the conservation or re-creation of more "natural" systems elsewhere along the Harbour perimeter or in Cootes Paradise. The City of Burlington embarked on a naturalization program for a park along the lower reaches of Grindstone Creek in part inspired by student work. The City of Hamilton took some of the ideas for a trail in the West Harbour area, and have further developed them as part of a major redevelopment plan proposal, and hired some Guelph students to assist with the work..

Sometimes the client chooses to further the work by hiring professionals. The steel products manufacturer, for example, retained the services of one of the authors, Larry Harder, working professional capacity, to develop a series of alternative site development plans for their property. This work was exhibited at the plant as a way to generate support for the ideas, although the economic concerns of the company precluded any imminent action on them.

There are other spin-offs from this work as well. Out of the student work, gaps in knowledge and new research needs are identified that help contribute to the understanding of the concepts and practical implementation of

restoration projects. As mentioned, it has been discovered, for example, that very little has been published on natural vegetation succession on heavily disturbed industrial sites, and that there are very major gaps in knowledge when it comes to particular kinds of conditions. For instance, out of mining reclamation research there is a lot of data on how to deal with high site acidity, but not very much that effectively addresses highly alkaline conditions. There has been little long-term monitoring of the success of reclamation projects, especially in the southern industrial areas of Canada.

The student research starts to address new areas of concern, and slowly adds to the body of knowledge related to restoration, rehabilitation and reclamation. The bias that the students bring to the research has to do less with pure science than it does with applied research that informs design, construction, and management. As landscape architects, this is the focus of their intentions.

As a result of these projects, students have researched a widening range of habitat types, including alvars, slough forests, carrs, robust "industrial forests" consisting of persistent pioneer woody species, and successional revegatation on toxic dredge spoils. They have explored wildlife habitat creation opportunities, such as restoration of habitat for fish and shoreline nesting birds, as well as wildlife pest control techniques, such as control of Canada geese and discouragement of cormorant nesting. They have tested the application of techniques such as bio-engineering and remedial wetlands, and explored the geometry of shorelines, islands, and stream alignments. They have explored alternative establishment techniques, such as the revegetation of woody plants on wastes using direct seeding techniques. They have explored species compositions adapted to particular kinds of site conditions. They have further examined site preparation strategies such as green manuring, cover cropping with nitrogen-fixing species, and application of bio-solid wastes as soil amendments. There have also been some extremely innovative exploratory design proposals including one proposal for floating islands and another for an "ecological freeway," comprised of a vegetated overpass to link several naturalization areas on either side of the Queen Elizabeth Way in Hamilton.

Some students who have been involved in these projects go on to develop their proposals further as competition entries or thesis work. A 1995 proposal for the heavily polluted Windermere Basin in Hamilton Harbour by students Glynis Logue and Scott Henderson, for example, was one of several projects coming out of this course work that won a Canadian Society of Landscape Architects student award. MLA thesis work has also evolved out of these projects. For example, former student Angela Coulas completed a thesis that looked at aspects of the physical design of decommissioned sites contaminated with extreme levels of radio-active wastes. Glynis Logue, was hired by the Royal Botanical Gardens for a summer to develop an amphibian habitat restoration project adjacent to Cootes Paradise, and has evolved her work into a thesis on design and management for amphibian metapopulations. Petra Kuehl has begun the exploration of revegetation patterns on industrial wastelands, and is working on a site in Pittsburgh. Other investigations have been also done or are on-going in the areas of wildlife habitat creation and phyto-remediation.

Conclusion

Industrial land reclamation is a very complex, multi-disciplinary endeavour, in which many participants play a variety of roles. There is no question that the task of reclamation is enormous, the challenges many, and the need great. The contributions of all players are necessary to advance our collective objectives of redressing the negative legacy of our industrial history. Landscape architecture, and landscape architecture graduate students are playing an important role in their own way in this endeavour. The circumstances related in this paper are a testament to what is possible. These examples point the way to the kinds of collaborations that will help us cast our gaze forward into that optimistic future.

Our students are our future. It is hoped that with experiences such as these, our students will be sent forth into the new millennium, as skilled professionals, ready to do their part with others, equipped with the right tools. ironically, to solve the problems of the past.

DEVELOPMENTS PAST, PRESENT AND FUTURE OF LANDS STRESSED BY THE MINING INDUSTRY.

T. H. Peters

ABSTRACT

A review of the relative impact of the four basic wealth creating industries and their impact on the environment and ecosystems.

This paper presents a review of the author's involvement in the reclamation of land stressed by the mining industry for the past 50+ years in various parts of Canada and to a lesser extent in other countries. The problems associated with the processing of ores in the more settled and populated regions of the country as well as in the more remote mining sites are discussed.

Current procedures and problems are touched on, as well as, a forecast of possible future developments in this field.

Introduction

It is difficult to realize while attending this Conference in the comparative luxury of this urban surrounding, that the wealth which permits this, is founded on four basic industries. The four are agriculture, the fishery, forestry and mining. The first three, agriculture, fishery and forestry are renewable resources. The fourth, mining, is a finite resource, although recycling of previously extracted minerals is a factor in meeting the ever increasing demand for these basic elements.

Although we can not create the products of the basic industries, we can increase their value by applying our time and labour to them.

Over the centuries and even currently man's mismanagement of the three renewable resources is evident to even the casual observer. Until this past century, what appeared to be unlimited new land or untapped resources were endless and were there to be exploited. We do not have to go far to see the folly of accepting these premises as they can readily be found in Canada. In agriculture, the continuance of practices causing the salination of our surface prairie soils or the ever increasing urban sprawl are but two examples of this folly. In the fishery, the depletion of the Atlantic cod stocks are equally matched in the forestry practices of the past 100 years of cutting and moving on without, until very recently, any replacement planting. This has reduced the amount of readily accessible sizeable timber to almost nil. In the case of of these renewable resources, we, as people tend to blame our predecessors, the changing climate, or the government for past mismanagement.

However, the mining industry, which adversely impacts on a much smaller, almost infinitismal, portion of the earth's surface com-

pared to the other three, does not have that advantage. During the past 50 years, various levels of government through their regulatory processes have required mining companies to remove almost all traces of their activivites on a site. In addition, the disturbed area must be returned to a condition which will not adversely impact on the local environment in the future. This requires the establishment of an ecosystem on the site which is comparable to the one that existed prior to any mining activity on the site.

The purpose of this paper is to examine what has happenned during the past 50 years, the base conditions from which we started, some of our successes and failures, current trends, and to take a look at the future, with particular reference to sulphide ores and the Sudbury, Ontario, mining area.

Discussion

The Past

The change from the roast yard smelting of sulphide ore, where the picked over ore was placed on cordwood piles and burned to eliminate the contained sulphur, took place at Inco in 1930. The introduction of the Herreschoff Roasters required a finely ground metal concentrate as feed. To obtain this quality of feed, it was necessary to grind the ore and extract a concentrate by a selective flotation process. The non metal bearing material (mill tailings) settles to the bottom of flotation cells and is pumped as a slurry to large holding areas known as tailings ponds.

Production at most Canadian mines during the 1930's was low. The tailings were usually deposited close to the mill in a small valley or in the case of gold mines, they were often deposited in lakes or ponds. However, the Canadian mines responded to the Allies call for minerals in World War II with greatly increased production. The Sudbury area mines supplied over 80% of the nickel required for the Allies' armament needs in ships, tanks, guns, aircraft, etc. By the end of the War, the tailings area at Copper Cliff, as in many other mining areas, had reached or surpassed the height of the surrounding hills. This height exposed the surface of the tailings to the prevailing winds and, under certain weather conditions, the small waste rock particles became airborne. This dust was a nuisance to the local residents and also affected adjacent industrial operations.

The mining companies soon realized that something had to be done and began experimenting with the use of snow fencing to minimize surface wind velocity, capping with bituminous sprays, limestone chip covers, etc, with little or no success.

My introduction to the problem began as a student employee in Inco Limited's Agricultural Department in the summer of 1947. I was assigned the task of planting some Twitch Grass (Agropyron repens) roots and rhizomes in a small test plot in the CD area. This test

was unsuccesful. Thus, I became involved in a 50 plus years search for an economically viable self sustaining procedure and material to stabilize tailings areas. The path of this reclamation/restoration program was to have many twists and turns as we were soon to discover.

As experience was gained from year to year, a list of practical procedural steps was developed. Although these procedural steps are now considered to be more or less site specific, their continual review and refining produced the following basic principles which are applicable to developing revegetation programs for any site (Peters,1995):

"1. Establishment of initial plant communities using available species that are tolerant of factors characteristic of the tailings. These factors include drought, low pH, poor soil texture, and the lack of organic materials and nutrients.
2. Modification of the local microclimate to benefit plant establishment.
3. Establishment of soil invertebrate and microbial communities. These assist in the soil building process and decompose naturally accumulating organic matter.
4. Establishment of nutrient cycles.
5. Establishment of a rich diverse plant community that can support wildlife and other natural assets."

The foregoing principles were, and are, much easier to successfully apply to non sulphide ore tailings such as the high silica tailings of the gold mines or the tailings of some of the copper or iron ores in which limestone is disseminated.

In the late 1970's, as answers to the problems of establishing a vegetative cover on tailings to control dust were being resolved, the downstream environmental problems associated with effluent seepage from sulphide tailings were becoming apparent. The mining industry recognized the need to find and implement a solution to this problem. This seepage became known as Acid Mine Drainage (AMD) or as Acid Rock Drainage (ARD). The continuous oxidation of the waste sulphides in the tailings or the piles of waste development rock was the initiating cause of the problem. Sulphides in the presence of atmospheric oxygen, some moisture, aided and abetted by various sub-species of the bacteria, Thiobacillus ferroxidans, progress through a complex series of chemical reactions which result in the generation of sulphuric acid.

This generated sulphuric acid, as it enters the interstitial soil solution, significantly lowers the pH of the seepage water thus allowing the heavy metals, copper, zinc, nickel, iron, etc., to come into solution. This solution became effluent as it seeped through the base of the dams or from the base of the waste rock piles. The elevated metal content of this seepage had a pronounced adverse effect on the indigeneous flora and fauna as it entered natural water courses.

During the latter part of the 1970's, two committees were formed to seek solutions to this problem. These were the National Uranium Tailings Study (NUTS) and the Reactive Tailings Study (RATS). They were composed of members from the federal Department of Energy, Mines and Resources and various mining companies. Both groups carried out some jointly funded research and met periodically to discuss results as they strove to solve the problem.

These two programs were replaced in the mid 1980's by the Mine Effluent Neutral Drainage (MEND) Program. Under this program experimental research projects, which were jointly funded by the federal government and individual mining companies, were undertaken. Although the program was centred on the theme of eliminating acid mine drainage, the individual research project was usually related to a particular problem at the site of the participating mining company. Immediate solutions based on engineering principles was the objective of most of the research work under this program. The information derived from the various research projects was freely exchanged.

In addition to the tailings related environmental problems, the mining industry was involved in finding solutions to problems caused by smelter, mine and other milling discharges and their impact on downstream air, water and soils.

Present

Today, as we look into the whole field of the restoration of land, water and air which has been stressed by the mining industry, we find that some solutions have been found but that we are still faced with challenges of related problems to be solved.

In the field of smelter emissions, the technical improvenments in the smelting processes has considerably reduced both the gaseous and particulate emissiions. Similarly, the required technology to treat process effluent water to meet the exacting government standards prior to its discharge to a natural water course is available. Waste rock piles will ultimately be deposited in abandoned mine shafts or open pits with any surplus rock being covered with overburden and vegetation. It still has to be borne in mind that there is a historic legacy of these problems, remaining at the many sites of past mining activities, which still have to be rectified.

The knowledge gained from the tailings research initiated under the MEND program of placing sulphide tailings under water has provided us with an alternative reclamation/restoration method. Mining companies can now make a choice of whether to use a vegetative or water cover. The choice which they make will have to provide a long term economically viable self sustaining solution. This is particularly true in remotre areas where the land will undoubtedly eventually revert to the Crown. In the short term, providing and maintaining a sufficient depth of water cover and maintaining the integrity of the tailing dams and the overflow effluent water dis-

charge points will be the work of the engineer. However, in the natural cycle of events, various species of flora and fauna will voluntarily invade the site and proceed to develop a site specific ecosystem. The managemnent and manipulation of the factors to accelerate the development desired components in this ecosystem requires the input of knowledgeable life scientists.

This new development of the use of water for a tailings cover has greatly increased the number of factors which must be considered in order to make the final decision of the procedure to be followed for a particular site. Although the addition and acceptance of the use of a water cover may be considered by some as a complication, it has certainly made the work of the present day reclamationist more interesting and challenging. There are now at least three basic types of cover which may be used, either singly or in combination. A knowledge of the basic characteristics of three covers, dry. vegetative and water is essential to making the correct selection of the one to be used at a particular site.

Dry or hard covers are an engineered covers which are designed to prevent, usually through the use of multiple layers, the infiltration of moisture or the surface growth of vegetation. In some countries where climatic conditions permit, they are used to cover uranium tailings. They are not too practical in Canada where moisture delivered by the annual precipitation usually exceeds the moisture lost by evapotranspiration at most sites. They are usually expensive to construct and to maintain.

The use of vegetative covers on tailings was initiated originally as a form of dust control on areas which had reached their final elevation. The first attempts were made using common agricultural practices to prepare and nutritionally ameliorate a seed bed 10 - 15 cm. deep. On sulphide tailings, vegetation establishment varied from site to site and from complete failure to reasonable success. Some sites require a layer of topsoil or clay of a sufficient depth to prvide an adequate seed bed. In certain areas, the outside tailings dam slopes with a south or south-westerly exposure require a 15 - 30 cm layer of clay to provide an adequate moisture retaining layer for plant growth. Costs will vary depending on the amelioration requirement of each site. As there is the potential for the introduction of undesirable elements into the food chain, an adequate monitoring program must be kept in place to assess this possibility. Although a transitional period is necessary to pass from the initial grass and legume cover, the final cover should be as close to and as diverse as the indigenous cover on the adjoining natural land. In the long term, the development of a self sustaining low maintenance cost oxygen barrier of decaying organic matter is the principle for using a vegetative cover. The plants ability to stablize the tailings surface and to intercept precipitation by providing suraces for evaporation plus the water transpired by the growing plants reduces the water infiltration into the tailings with the consequent reduction in seepage.

Water covers, as stated previously, form an immediate oxygen barrier over the tailings and in the case of uranium tailings, eliminate the escape of radon and other members of the radionuclide group. Physically water has many of the characteristics that are sought in an engineered cover (Kirkwood, 1996). Water is flexible, can deform and remain intact. This is essential under the wide range and fluctuations experienced in the climate of northern Canada. Aestheically, a water cover does not seem out of place in northern mining areas where wetlands, ponds and lakes are integral features of the landscape. Provisions must be made to monitor and maintain the dams and related structures for the years to come. Arrangements to remove excess water during flooding conditions and supplementing the supply of water during drought conditions must be included in the plan of operation. The cost per acre to establish and maintain a water cover is, similar to a vegetative cover, high. Conversion of established tailings area to a water covered one, can be costly. It often involves new dam construction, recontouring the tailings surface, moving tailings to specific areas and the construction of new effluent discharge and treatment facilities. An insight into these costs can be gleaned from a review of the Dennison Mines Ltd. and Rio Algom Mines Ltd. Environmental Impact Statements for the closing out of their waste management areas at Elliot Lake, Ontario. On the other hand, costs can be more reasonable if the plan to use a water cover is an integral part of the planning of a new operation.

Before considering the future, I would be remiss if I did not mention the success achieved of the Greening of Sudbury Program in the restoration of the land stressed by smelter emissions. The Regional Municipality of Sudbury, under the Chairmanship of the late Tom Davies, establihed the Vegetation Enhancement Technical Advisory Committee in the early 1970's. Representatives from various government ministries, local colleges, Laurentian University, the local mining and other companies, local organizations along with some interested citizens make up the Committee. The necessary administration duties are handled by the Region's Planning Department. Under its aegis, some 3,000 + hectares have been treated with over 3 million trees planted. In addition the Committee has worked with different groups to solve the problems associated with the revegetation of this stressed land. Ideas have freely discussed over the years and an overall will to get the job done prevails on this Committee.

Among the many successes in the Program, there are two which stand out in my opinion. Although both were anticipated in the long term, their early and rapid development was unexpected. The first was the rapid and successful invasion of locally indigenous species of trees. Paper birches (Betula papyrifera) and trembling aspen (Populus tremuloides)voluntarily invaded the area in large numbers once the seed bed had been nutritionally ameliorated and persisted where the soil surface had been stabilized by the seeded grasses and legumes. The other was the rapid improvement in the water quality and ph of the lakes whose surrounding slopes and shores had been

revegetated and planted with trees.

Graduate and undergraduate students from many universities have undertaken research in their varied disciplines on the many problems encountered in the land restoration work in the Sudbury - Elliot Lake areas. Both VETAC and the mining companies have benefitted from their work.

The Future

As I look into the future, I am impressed with the speed of transition with which the knowledge gained from research projects is integrated into practical field applications. The review of past practices have led to their modification and in some cases, the discovery of unpredicted benefits. The unforeseen and and not anticipated benefit of the water retention capability of the clay spread as a cover of the southerly oriented outside slopes of the tailings dams at Copper Cliff is but one example. The clay was originally installed to provide an adequate moisture reserve for seedling establishment has doubled as a partial oxygen barrier reducing the oxidation rate of the tailings underneath and the subsequent acid generation.

The threshold from research to field application of the use of large scale water covers has just been crossed. The knowledge and experience to be gained, particularly from the Mineral Waste Management Areas at Elliot Lake, has many facets from which we can learn as they unfold in future years. Preliminary reports (Payne and Ludgate, 1998) indicate that the improvement in the surface effluent water discharge from these areas is meeting or exceeding expectations. Research continues on the selection and methods of establishment of aquatic vegetation. There has been a slow but steady invasion of aquatic plants which indicates that these ponds will eventually in time develop a vegetative complex similar to the natural ponds and lakes in the surrounding area.

It is not practicable or economically justifiable to place many existing tailings areas under water. In the case of non-sulphide ores, acid generastion is not a problem. Many of the historic abandoned sites are in remote areas where the former access roads have become overgrown or eroded, thus the cost of establishing access for regular routine inspections and maintence in these cases is usually not acceptable. The use of a vegetative cover remains a realistic solution for these sites.

In order for a vegetative cover to be considered a success, it must be self sustaining with the capability, when covering sulphide wastes, to build up and maintain a sufficient depth of organic matter to form a continuous oxygen barrier. This ability, along with climatic and geographic factors, is of prime concern when selecting the plant species which are to be used in the cover. Throughout the Laurentian Shield, conifers are accepted as the climax vegetative cover. However, in its evolution this coniferous forest was preced-

ed by a transition period when deciduous species formed the dominant portion of the cover. The vast amounts of leaf detritus from their annual shedding was the major source of the organic material which facilitated the early soil formation in the area. The inclusion of more deciduous tree and shrub species in our reclamation programs is, in my opinion, a practice which should be implemented. This will also assist in the development of a more biologically diverse ecosystem at each site. In order to recycle the nutrients in this increased abundance of organic matter, attention will have to be given to developing methods to naturally increase the amount and availability of nitrogen present to the level required by the increased activity of the decomposition. The sooner our management practices reflect the acceptance of this need, the sooner our objective of a self-sustaining maintenance free system will be achieved.

It is worthy to note that Inco Limited has foreseen this need, and although it has successfully revegetated its inactive tailings areas, has undertaken a joint research progeram with Laurentian University to determine the quantity and diversity of the flora and fauna present in the Copper Cliff Tailings Area (Bagatto, Shorthouse, Beckett, Winterhalder, 1998). The information gained will be utilized in developing future management programs.

There are even more interesting challenges to be considered in the slightly more distant future. Due to the rapidly increasing world population and the corresponding acceleration in the need for food and fibre, there is a possibilty that our industrially stressed areas could be used to meet some of this need.

For many years, the "spoils" from the tin mining operations in South East Asia have been reclaimed as cattle pasture or used as rice paddies (Kitching, 1978). Various governments in that part of the world have investigated the potential for production of various agricultural crops for home consumption or for revenue producing export. Shrimp have been produced in some mine waste ponds. In this densely populated part of the world there is a great need of protein. As we progress, the possibility of using reclaimed/restored land or ponds for meat and fish production must be further pursued.

In the Philippines, consideration has been given growing certain leguminous trees andd shrubs to stabilize tailings areas. The leaves and twigs of these tree can be used as cattle fodder while the larger branches and trunks can be utilized for firewood or manufactured into charcoal for cooking (Kitching, 1978). Both beef and dairy cattle are pastured on reclaimed land which had been previously disturbed in the production of aluminum.

Closer to home in the Kamloops area of British Columbia, the use of vigorous stands of alfalfa (Medicago sativa) forming the vegetative cover on extensive acreages of copper tailings is is being investigated for its potential of providing additional acreages of high quality pasture for local ranchers (Jones, 1996, Gardner et al,

1996). The current relaxation of the federal regulations on the growing of industrial hemp (Cannabis sativa) for fibre, has brought forth inquiries from some entrepreneurs to consultants about the use of tailings areas as producing fields.

Maybe the mining industry will become a small but important source of food and fibre in the future. When we consider that the amount of arable food producing land per person on this globe has fallen from 3/4' of an acre to 1/2 of an acre in the last 25 years, the need to consider and implement this end use is glaringly evident.

In closing, I would remind all who are or who will become engaged in land restoration of industrially stressed sites to remember the following words "Adapt, not Adopt" the practices followed and observed at other sites to the conditions with which you are facing on your current job site. I would also remind everyone to consider and remember the motto of the British Columbia Mining Association "If it can't be grown, its got to be mined".

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Roger Payne, Rio Algom Mines Ltd., Elliot Lake.
Ian Ludgate, Dennison Mines Ltd., Elliot Lake.

Dr. Peter Beckett, Laurentian University.
Professor Keith Winterhalder, Laurentian University.
Dr. J. Shorthouse, Laurentian University.
Mr. G, Bagatto, Laurentian University.

A TEST OF PLANT-AIDED PETROLEUM HYDROCARBON DEGRADATION

Kevin R. Hosler*, and E.N. Drake**

*Water Technology International Corporation (a Division of Conor Pacific Environmental Technologies Inc.), Burlington, ON.

**Exxon Research Engineering Company, Annandale, NJ.

ABSTRACT

One of the mandates of WTI's Assessment & Remediation Technical Area is to research and develop environmental restoration technologies, especially those applicable to contaminated industrial sites. One technology that may prove useful for restoring contaminated sites is *phytoremediation.* The applied use of plants for restoring anthropogenically-contaminated environments may prove to be a simple, cost-effective clean-up option for specific sites, under certain conditions.

A greenhouse-based phytoremediation experiment was performed to assess the potential impacts of three treatment factors on the degradation of petroleum hydrocarbons in contaminated soils. A 2^3 factorial experimental design - replicated twice for a total of 16 experimental units – was used. The three factors tested were: 1) turfgrass (a 50:50 mixture of tall fescue and perennial ryegrass); 2) BuRIZE™ (a commercial "vesicular-arbuscular mycorrhizal", or VAM, inoculant); and 3) fertilizer (a commercial liquid formulation). Controls consisted of untreated contaminated soil. The design allowed for testing of any significant differences in contaminant degradation rates resulting from use of the three treatments, individually and jointly. Four sampling events (i.e., an initial, two interim, and a final) occurred over a study period of 180 days. Statistical evaluation of the experimental results revealed a consistent, significant treatment effect for the "fertilizer" factor and a periodic treatment effect for the "grass" and "grass/VAM inoculant" interaction.

This work was supported by Environment Canada, and involved collaboration between Water Technology International Corporation (WTI; Burlington, Ontario), Exxon Research & Engineering Company (Exxon; Annandale, New Jersey), and Imperial Oil Ltd. (IOL; Sarnia, Ontario).

Introduction

This publication describes the results of one part of a phytoremediation research program to assess the use of turfgrasses and other plants for enhancing the *in situ* degradation of petroleum hydrocarbons under conditions that would mimic potential large-scale phytoremediation operations. The overall research program involved two separate but related parts; Part I involved a multi-year field study, and Part II involved a greenhouse "potted plant" study. The field and greenhouse studies were designed to complement one another, such that results could be compared/corroborated. Only the greenhouse research study will be discussed here.

Phytoremediation[1] is the name given to a class of distinct technologies that use particular plant species to restore contaminated environmental matrices. Phytoremediation technologies exploit the unique abilities of the plant species to:

- degrade or facilitate degradation of predominantly organic contaminants alone or via microbial associations within the plant rhizosphere;
- hyperaccumulate or sequester predominantly inorganic contaminants within plant parts (e.g., roots, shoots, stems, leaves);
- bind / stabilize contaminants within plant parts or within the rhizosphere;
- uptake volatile organic contaminants from the rhizosphere and translocate and transpire them into the atmosphere;
- perform other metabolic functions that result in enhanced de-contamination of environmental matrices.

Methods to study, and enhance the biodegradation or bioremediation of organic contaminants such as petroleum hydrocarbons - or their constituent polycyclic aromatic hydrocarbon (PAH) compounds - have been researched by WTI scientists since the early 1980's (e.g., Bulman *et al.*, 1985, 1988; Hosler *et al.*, 1992; Hosler and Booth, 1996). This research revealed that biologically-aided contaminant degradation may often be enhanced by various treatments (e.g., adding nutrients in the form of inorganic fertilizers or manure; adding oxygen or other electron acceptors; modifying soil conditions, etc.). Recently, research has shown that contaminant degradation may also be enhanced in the rhizosphere or root-zone of various plant species (e.g., April and Sims, 1990; Banks *et al.*, 1997; Qui *et al.*, 1997). Remediation of particular contaminants may be achieved by exploiting the unique symbiotic associations between certain fungal species and plant roots, called "mycorrhiza" (literally, *fungus-root)*. Inoculation of soils with mycorrhizal fungi for enhancing agricultural production is a common practice supported by various commercial companies (e.g., Buckman Laboratories of Canada Ltd.). Plants have an inherent ability to aerate, bind and/or stabilize soils at contaminated sites (e.g., reducing or eliminating erosion, and regulating water infiltration), and thus their presence is undoubtedly advantageous. However, more research is needed to show that plants – in phytoremediation applications - provide a distinct and significant benefit above that of general "bioremediation" processes, which have proven effective in degrading various environmental contaminants, both *in situ* and *ex situ* (e.g., see AAEE/Wastech, 1995).

Experimental Design

A 2^3 factorial experimental design was used in a greenhouse study to assess the degradation of "total petroleum hydrocarbons" (TPH) – the nomenclature that we will use to represent a "weathered crude oil" - in contaminated soil. Factorial treatment designs allow a researcher to evaluate the effects of one or more "factors", taking into account the simultaneous effects of other treatment factors, thus producing efficient experiments (Kuehl, 1994). Our design evaluated the effects of three factors:

(1) a 50:50 mixture by seed quantity - or 3:2 ratio by seed weight - of tall fescue [*Festuca arundinacea* var. "Bonsai"] and perennial ryegrass [*Lolium perenne* var. "Affinity"], applied at a rate of 5 g/pot;
(2) BuRIZE™ (a commercial vesicular-arbuscular mycorrhizal inoculant; Buckman Laboratories of Canada Ltd.; Vaudreuil, PQ), applied at a rate of 1 propagule VAM/cm^3; and,
(3) a commercial liquid fertilizer formulation ("Schultz-Instant®" water; Schultz Co., St. Louis, MO; guaranteed analysis of 10% total N, 15% available P_2O_5, and 10% soluble K_2O; mix formulation of 7 mL fertilizer/1L water), applied at the rate of ~150 mL mix per pot every three days.

[1] *Phyto* - combining form of the Greek word *phyton*, plant (Gage Canadian Dictionary, 1980)

The factors were tested at two levels each (i.e., either present or absent), and can be summarized as follows:

Treatment #1 Contaminated soil.....(no factors)
Treatment #2 Contaminated soil + grass.....(factor "A")
Treatment #3 Contaminated soil + fertilizer.....(factor "B")
Treatment #4 Contaminated soil + BuRIZE™ .....(factor "C")
Treatment #5 Contaminated soil + grass + fertilizer.....(factors "AB")
Treatment #6 Contaminated soil + grass + BuRIZE™ .....(factors "AC")
Treatment #7 Contaminated soil + fertilizer + BuRIZE™ .....(factors "BC")
Treatment #8 Contaminated soil + grass + fertilizer + BuRIZE™ .....(factors "ABC")

Treatment #1 represented the "control", as referred to in subsequent tables and Figure 1. There were two (2) replicates of the experimental units (i.e., ceramic plant pots, 205 cm in diameter and 153 cm in height; containing 1833 g of mixed soil) for each treatment, for a total of sixteen (16) pots. For a subjective evaluation of the quality and quantity of grass growth in uncontaminated versus contaminated soil, another two (2) pots were set-up with clean (uncontaminated soil) and all treatment factors were applied (i.e., the "subjective" control). This assessment of grass growth helped to determine if the contaminated soil had any toxic effect on the plants. This treatment was not sampled for TPH, as sufficient QA/QC samples had been included in the sampling program to assess "background" or uncontaminated soil TPH concentrations.

The plant pots were incubated on a table in a research greenhouse with relatively constant temperature (23°C+/-3°C), humidity, and a 12-hour photoperiod. Natural radiant energy was supplemented by two 400-watt metal halide lamps (HDK Luminaires; Philips Electronics Ltd.). A pot location grid was prepared on the table to facilitate the randomized pot placement; to avoid any confounding environmental variables (e.g., temperature, illuminance).

Experimental Set-Up

Contaminated soil - collected from the field site "hotspot" at a depth of approximately 25 cm - was sieved to <2 mm size (U.S.A. Standard Testing Sieve No. 10; Tyler Equivalent 9 Mesh, W.S. Tyler Inc.) and then stored at 4°C until ready for use. "Clean" soil from the A_h horizon (i.e., the dark-coloured horizon enriched in organic matter) of a non-cultivated rural agricultural field was similarly sieved and stored. Prior to and during their use in the study, both soils were characterized for basic physico-chemical properties previously shown to influence bioremediation processes (Sims *et al.*, 1989; Hosler & Booth, 1996). Also, three replicated samples of both contaminated and clean soils were characterized for total heterotrophic plate counts and quantity of TPH-degrading microorganisms using standard methods; diesel fuel was used as the organic substrate for isolating the TPH-degraders.

For this study, an approximate 1:4 mix ratio of contaminated to clean soil was used, because preliminary testing had shown that the 3.5% - 5% range of contamination in the "raw" contaminated soil was severely detrimental to plant growth. The contaminated soil was mixed with the clean soil as follows. A pre-weighed amount of contaminated soil was mixed with a pre-weighed amount of clean soil within a Nalgene-brand HDPE container ~45 cm x 70 cm x 35 cm deep, by successively applying small aliquots of contaminated soil to a single layer of clean soil. This soil was then mixed thoroughly, and the process repeated until the entire mixture was visually homogenous - after approximately 20 minutes of hand mixing. The mixed soil was then distributed to individual experimental units (pots) in a randomized order. Soil sampling was then performed (described in detail below). After the sampling, all pots received equal amounts of sufficient water to initiate seed

germination, followed by additions of specific treatment amendments (i.e., grass, BuRIZE™ VAM inoculant, fertilizer)(see **"Treatment Application"**, below).

Soil Sampling

Soil sampling was performed in a uniform manner using a stainless steel scoopula. An approximate 50 g sample was taken from one of four quadrants or designated spots in each pot; a separate quadrant was used for each sampling event. Samples were thoroughly mixed prior to submission to an independent analytical laboratory. Appropriate and sufficient numbers of QA/QC samples (i.e., controls, spikes, duplicates, and method blanks), were included in the study. After grass growth had occurred in specific treatment pots, soil sampling involved "coring" the turf and removing it, removing all adhered soil from the plant roots, and adding it to the remainder of the soil sampled from deeper in the pot.

The sample schedule was originally designed to have three sampling events, but this was later expanded to four when the exhibited TPH degradation was lower than anticipated after three periods. Timing of the sampling events was based upon "typical" TPH degradation rates reported in the literature (e.g., Huesemann, 1994; Visser *et al.*, 1987).

Treatment Application

After initial soil sampling, an equivalent amount of moisture was added to all experimental units (pots). Hydrocarbon-contaminated soils are typically very hydrophobic and moisture addition to "air-dried" soils can often be problematic. Extensive mixing was thus required before the soils absorbed enough water to achieve the desired moisture content of 70% of maximum water holding capacity - as determined by standard methods.

Grass seeds were planted in designated treatment pots as follows. A suitable quantity of a 50:50 mixture of tall fescue and perennial ryegrass seeds (60:40 mixture by weight) was first prepared. The surface layer of soil in the respective treatment pots was then removed and held in a tinfoil weigh-boat. At this point, pots designated for inoculation with BuRIZE™ VAM (prepared as per the manufacturer's instructions) received the liquid inoculant; added to the exposed subsoil. An appropriate quantity of grass seed was then distributed onto the wetted soils and dry soil was sprinkled over-top to secure the seeds. More water - which may or may not have had liquid fertilizer added as per the designated treatments - was then applied.

Germination of the plants occurred after approximately seven days but was not uniform because a thin soil crust prevented "normal" germination in some pots. Plants attained a height of >8 cm in the uncontaminated controls whereas plants in the contaminated pots were noticeably less prolific. The soil crusts persisted in most pots after two weeks and were then manually "disrupted" to allow uniform grass development. After three weeks, grass growth was relatively uniform amongst all treatment pots, however clean soil controls continued to exhibit superior growth.

Results

The physico-chemical characterization of both "clean" and "contaminated" soils revealed that the critical environmental factors necessary for bioremediation of petroleum hydrocarbons (e.g., temperature, moisture content, pH, cation exchange capacity, etc.) were within acceptable levels (e.g., see Table 3., J.L. Sims *et al.*, 1989). Characterization of the heterotrophic and TPH-degrading microbial populations revealed that both of the soils individually possessed "reasonably-sized" heterotrophic and TPH-degrading microbial populations (i.e., > 1.0×10^5 cfu/g). It would thus be reasonable to expect some biodegradation of the hydrocarbon contamination during the course of the study.

Initial soil sampling results from the 16 experimental units revealed a relatively uniform mixing of contaminated hotspot soil with clean soil, displaying an average TPH concentration of 6,875 ppm with a standard deviation of 522 and a coefficient of variation (CV) of 7.6%[2]. Summary statistics for the overall TPH data are presented in **Table 1.** It would be expected that as the experiment progressed, the variation in the overall mean TPH value would increase because the differences between treatments and controls (i.e., treatment effects) should increase (i.e., a greater dispersion of the data around the overall mean), and this result did occur.

Table 1. Summary statistics for the TPH data; combined treatments and controls.

Sample Period	Mean TPH (ppm)*	Standard Deviation (ppm)	%CV
#1 (0 days)	6,875	522	7.6%
#2 (66 days)	4,606	580	12.6%
#3 (88 days)	4,000	661	16.5%
#4 (188 days)	2,731	953	34.9%

* = Note that this is for all treatments and controls, averaged together.

The replicate average TPH concentrations, with standard deviation values, are presented for all treatments for the four time periods in **Table 2**.

Table 2. Replicate average TPH concentrations (ppm) versus time, with standard deviations.

Treatment	Time (d)	TPH Avg.	Std. Dev.	Treatment	Time (d)	TPH Avg.	Std. Dev.
Control	0	6350	919	Control	66	4800	141
A	0	7000	141	A	66	5200	283
B	0	7100	566	B	66	4850	354
C	0	6900	849	C	66	3900	0
AB	0	7200	141	AB	66	5400	141
AC	0	7150	495	AC	66	4200	849
BC	0	6800	707	BC	66	4150	71
ABC	0	6500	283	ABC	66	4350	212

[2] The *anticipated* or *target* TPH concentration had been 7,066 ppm TPH, based upon hotspot soil sample characterization.

Table 2. ***continued.***

Treatment	Time (d)	TPH Avg.	Std. Dev.	Treatment	Time (d)	TPH Avg.	Std. Dev.
Control	**88**	4800	283	Control	**180**	3600	283
A	**88**	4300	990	A	**180**	3750	495
B	**88**	4550	71	B	**180**	3250	495
C	**88**	4150	778	C	**180**	1900	707
AB	**88**	4650	71	AB	**180**	3700	141
AC	**88**	3100	283	AC	**180**	1900	283
BC	**88**	3450	71	BC	**180**	1500	424
ABC	**88**	3800	141	ABC	**180**	2250	71

The TPH "loss" data for all treatments for the four sampling periods is graphically presented in **Figure 1**, which displays a 3-D column chart of the "ranked" treatments (i.e., highest "loss" treatment [BC] shown in the foreground, and lowest "loss" treatment [Control] shown in the background).

The experimental hypothesis for this study was that the use of turfgrass should result in greater TPH degradation as compared to those treatments without turfgrass. The use of a factorial treatment design allows one to assess a number of factors to determine if there are significant effects on TPH degradation from using the treatments, or factors, alone (i.e., "simple effects"), or in combination (i.e., "interactions"). The analysis of the data was performed in a manner similar to methods outlined in Chapter 5 of Cochran & Cox (1992), however using a *STATISTICA®* software package (StatSoft®, Tulsa, OK). The data was analysed for all (four) time periods – individually, and in combination (i.e., periods #1, #2, #3, & #4, periods #1&#2, periods #2&#3, periods #3&#4, and periods #1&#4). All individual and combinations of factors were assessed to determine which effects were statistically significant for enhancing TPH "loss" (assumed to be "degradation"). The results may be summarized as follows:

- For time periods #1&#2, both "fertilizer" and "time" factors were statistically significant, and there was a significant "fertilizer/time" interaction;
- For time periods #2&#3, both "fertilizer" and "time" factors were statistically significant, and there was a significant "grass/time" interaction;
- For time periods #3&#4, both "fertilizer" and "time" factors were statistically significant, and there were significant "grass/VAM inoculant" and "fertilizer/time" interactions;
- For time periods #1&#4, both "fertilizer" and "time" factors were statistically significant, and there was a significant "fertilizer/time" interaction.

For brevity, only one of the ANOVA tables is presented below to illustrate the type of analysis performed (**Table 3**). This ANOVA table shows two significant factors and one interaction; ***all time periods were considered for the analysis.***

Table 3. ANOVA for the 2^3 factorial experiment; all time periods; significant effects are bolded.

Source	Sums of Squares	Df*	Mean squares (effect)	F-value	p-value
"A" (Turfgrass)	360000	1	360000	1.669	.205
"B" (BuRIZE VAM)	15625	1	15625	.072	.789
"C" (Fertilizer)	1314000	1	1314000	**60.942**	**.000**
"T" (Time)	142655700	3	47551900	**220.530**	**.000**
"AB"	250000	1	250000	1.159	.289
"AC"	122500	1	122500	.568	.456
"BC"	105625	1	105625	.489	.489
"AT"	1046250	3	348750	1.617	.204
"BT"	153126	3	51042	.236	.870
"CT"	5213124	3	1737708	**8.058**	**.000**
"ABC"	62500	1	62500	.289	.594
"ABT"	1328751	3	442917	2.054	.125
"ACT"	116250	3	38750	.179	.909
"BCT"	655626	3	218542	1.013	.399
"ABCT"	163749	3	54583	.253	.858

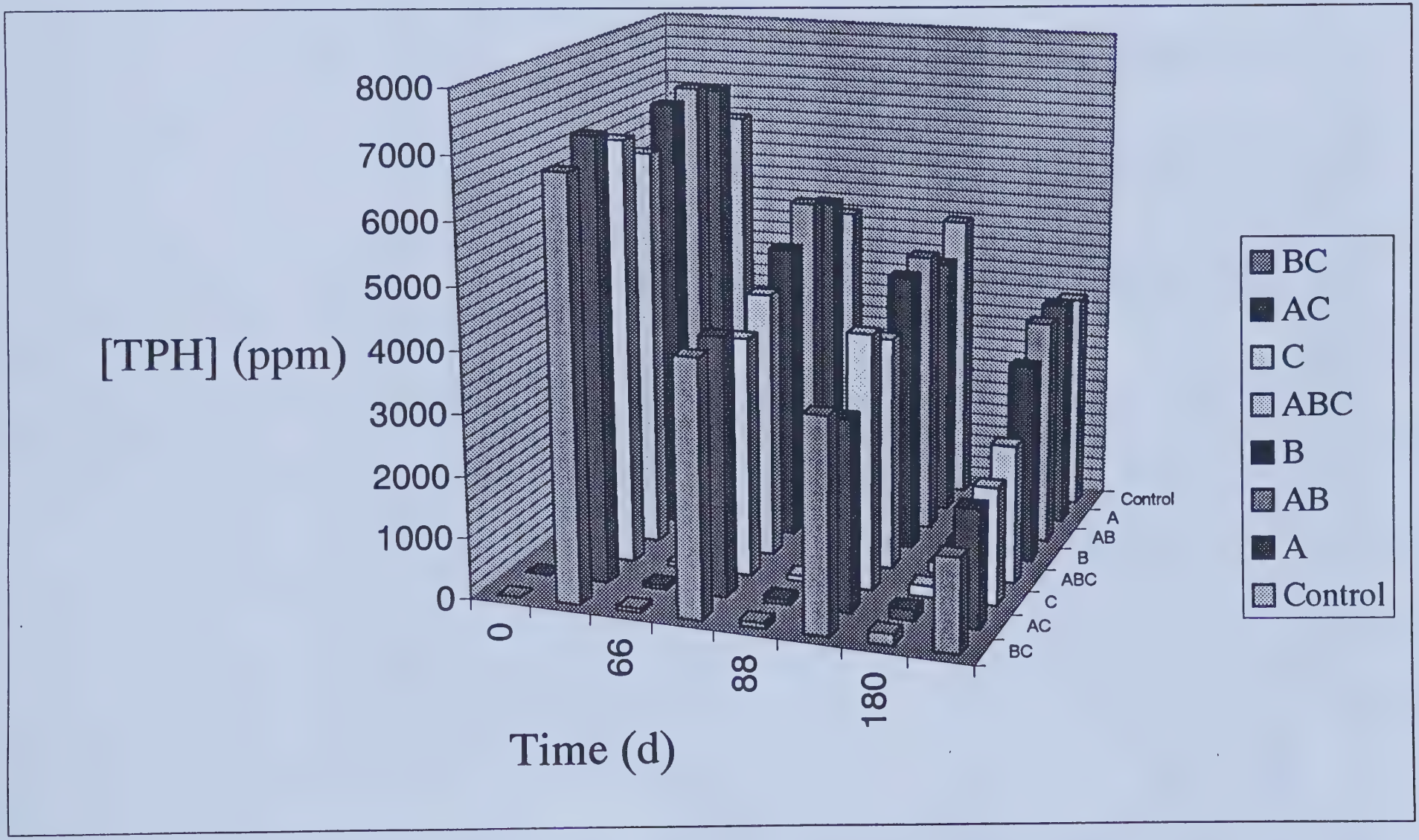
* = degrees of freedom for the effect.

Discussion

The statistical data analysis suggests the following conclusions regarding the important factors for enhancing TPH "degradation" during the course of the study:

- Two factors were consistently significant during the full study period (i.e., for the four time intervals tested). Significant effects were displayed by both the "fertilizer" and "time" factors. One would assume that the "time" factor would be significant since TPH degradation is known to occur abiotically in soils during time periods much less than the 180-days studied here. A significant effect for the "fertilizer" factor is reasonable given that bioremediation of petroleum hydrocarbons is commonly enhanced by the addition of inorganic fertilizers.
- A "grass / time" and a "grass / VAM inoculant" interaction each occurred in just one instance. The "grass / time" interaction occurred between periods #2 and #3 (66 and 88 days) and it was during this time that the rate of grass growth was quite high. The "grass / VAM inoculant" interaction might possibly be attributed to a mycorrhizal growth effect that enhanced TPH degradation during the last 92 days of the study (i.e., between periods #3 and #4).

Figure 1. **3-D column chart of TPH concentration versus time for the 8 "ranked" treatments; highest "loss" treatment appears in the foreground and lowest "loss" treatment appears in the background.**



As displayed in **Figure 1**, all treatments - including the control - showed decreasing TPH concentrations (replicate averages) during the course of the experiment, however the control showed the lowest decrease. Some of the reduction in TPH concentrations may be attributed to physico-chemical processes that were not experimentally controlled - such as volatilization, leaching, sorption, hydrolysis, and photodegradation - however these processes are assumed to be negligible in this study. Thus, decreasing TPH values may reasonably be labelled as "degradation" or more likely "biodegradation".

In conclusion, this experiment was designed to allow an assessment of several potentially important factors for enhancing the "loss" or "degradation" of TPH from contaminated soil. All of the treatments showed greater TPH "loss" – assumed to be caused by biological degradation - than the control. The detailed statistical analysis revealed a consistent, significant effect for the "time" factor, the "fertilizer" simple effect, and a "fertilizer/time" interaction. A "grass/time" interaction and a "grass/VAM inoculant" interaction significantly enhanced TPH degradation, but only for two time periods. The possible reasons for these results may be as follows:

1. For the "grass" treatment, the level of contamination used in this study (~6875 ppm) had an obvious deleterious effect on the growth of the grass plants – possibly due to the hydrophobic nature of the petroleum and its negative effect on soil moisture retention and soil compaction. The plants in the uncontaminated, fertilized, "subjective" controls displayed much more vigorous and healthy-looking growth than all other plants, including those in the contaminated soil treatment receiving all three factors (ABC).
2. For the BuRIZE™ VAM inoculation, fungal hyphae were observed in only one of the two "grass + inoculated" treatment pots, at the second sampling period (i.e., at 66 days). After this period however, hyphae were not readily observed in the pots. It is possible that VAM populations did not establish sufficient populations for aiding TPH degradation during the full course of the study.
3. The contaminated soil contained a large amount of "microbially-available carbon". It is well-documented in the bioremediation literature (e.g., Sims *et al.*, 1989) that a "carbon:nitrogen ratio" of approximately 12:1 (or thereabouts) is required for microbial growth and function via substrate metabolism. Since non-leguminous (i.e., non-Nitrogen-fixing) plants were used, it is possible that the amount of Nitrogen available to the microorganisms was the limiting factor for microbial growth, and the presence of plants and/or mycorrhizae could not improve upon this situation.

Although this experiment did not show a consistent, significant enhancement of TPH degradation resulting from turfgrass planting, it did reveal periodic enhancements resulting from the factors tested. There are several important benefits that plants may provide to contaminated site remediation that were not tested in this study. Plants have an inherent ability to aerate, bind and/or stabilize soils at contaminated sites (e.g., reducing or eliminating erosion, and regulating water infiltration). Recent research has shown that phenolic compounds released as root exudates from certain plant species (e.g., Mulberry, Osage Orange), may enhance the degradation of specific compounds such as polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs)(Fletcher, 1998). If contaminant degradation and/or stabilization can be achieved *in situ* by plants, remediation costs for specific sites could be considerably reduced versus the use of more intensive bioremediation technologies such as biopiles, bioventing, or physico-chemical technologies such as soil washing or thermal destruction. Further testing of the specific benefits that may be provided by plants at contaminated sites is recommended in order to facilitate optimization of phytoremediation processes.

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A NATURAL HERITAGE APPROACH TO THE REHABILITATION OF SOUTHERN ONTARIO'S LIMESTONE QUARRIES

Ken Ursic (presenter), **Margot Ursic and James Dougan**

Dougan & Associates Ecological Consulting Services
Guelph, Ontario

Abstract

Southern Ontario's disused pits and quarries are typically viewed as visually unattractive landscape features that must be transformed into agricultural lands or turf-style recreational areas. This type of rehabilitation involves the costly and labour intensive processes of backfilling, site grading, landscaping and maintenance. These processes introduce artificial elements into the landscape, contributing to its' already fragmented and unnatural character.

This paper presents a cost-effective rehabilitation approach consistent with Provincial and Regional natural heritage objectives. The natural heritage approach involves changes in how we view abandoned quarries and how we manage their rehabilitation. Although this concept can be applied to abandoned pits, the focus of this paper will be on limestone quarries. The first step is to view abandoned quarries as potentially beautiful landscapes that could be habitats for rare and common native species of vegetation and wildlife. The second step is to look at the natural analogs of limestone quarries that occur in southern Ontario, namely the Niagara Escarpment and alvar habitats, for models of natural rehabilitation.

Research conducted by the principal author in southern Ontario and others in Great Britain has shown that, given time and the proper environmental conditions, abandoned quarries will develop vegetation communities comparable to those found in their natural analogs. Several modifications of existing quarrying practices, such as the use of restoration blasting, in conjunction with seeding and planting of site-appropriate native species have been shown to accelerate the processes of natural revegetation. A natural heritage approach to rehabilitation should work towards embracing natural successional processes so that disused pits and quarries are transformed to natural endpoints within the landscape.

Introduction

Current policy in Ontario requires site rehabilitation plans in support of applications for new or expanded quarry extraction. Although rehabilitation can entail attempts to restore the quarry to a former land use, this is not always required and is often neither practical nor desirable. Depending on the location and size of a quarry, as well as the objectives of the key stakeholders, a former quarry may be rehabilitated to agricultural, silvicultural, residential, commercial, industrial, recreational or "natural" (i.e. conservation) lands (Mackintosh and Hoffman 1985; Hilditch et al. 1988; Yundt and Augaitis 1992).

There has been a significant amount of research on and discussion of quarry rehabilitation for agricultural, silvicultural and recreational purposes, but restoration tfor conservation has been only explored to a limited extent

in Ontario. Key recommendations have typically involved backfilling, costly importation of sub-soil and topsoil, and plantings of trees and shrubs that are not native and/or not suited to the rigours of a quarry habitat (Lowe 1979; Hilditch et al. 1988; Yundt and Augaitis 1992). The natural heritage option presents the greatest ecological potential, but is seldom selected due to lack of available research.

Although limestone quarries in Ontario are typically considered unsightly and potentially dangerous landscape features, there is a growing recognition among rehabilitation scientists and practitioners that these sites represent opportunities for the creation of relatively high quality, self-sustaining ecological landscapes. Current research in Ontario and Great Britain has shown that given time and the right environmental conditions, disused quarries become colonized with flora and fauna comparable to that of natural analogs in those regions (Coppin and Bradshaw 1982; Gunn et al. 1992; Wheater and Cullen 1997; Ursic et al. 1997). These anthropogenically created landscapes provide potential refuges for rare and uncommon native species, as well as potentially valuable passive recreation facilities, if safety issues are addressed.

The focus of this paper will be the natural heritage approach to limestone quarry rehabilitation, based on the authors' familiarity with the geology and vegetation dynamics of limestone habitats. However, this approach canalso be applied to gravel pits which have simliar natural analogs (beaches, barrens and bluffs) in Ontario.

Historical Context

Limestone has been quarried in southern Ontario for more than 250 years, with the first pits operating in the vicinity of present-day Toronto in the 1720's (Yundt and Augaitis 1992). Until the 1900's, most of these quarries were excavated manually using 'plug and feather' techniques which removed individual blocks of stone along existing bedding planes of naturally exposed escarpments. These relatively small, exposed limestone faces, if left intact, were typically surrounded by existing natural vegetation communities and became re-colonized, blending in with the natural landscape within several decades. The introduction of primitive blasting methods, using black powder, resulted in stable, heterogeneous quarry faces containing microsites for colonization by local vegetation.

The advent of modern explosives and the increasing demand for limestone for use in roads and urban structures, caused quarries to changed dramatically in size and appearance. Modern explosives (TNT, ANFO) expand rapidly at high temperature and pressure, causing an intense shock wave which results in a highly fractured, uniform sterile face (Gunn et al.1992; Gunn and Bailey 1993). Modern transportation and limestone processing technologies have permitted more intensive extraction, resulting in larger and deeper quarries that frequently extend below the water table. Large quarries, with unstable walls and frequent isolation from analogous natural vegetation communities, take much longer to become colonized, and therefore require considerable planning and active management if they are to blend into the existing natural landscape within a reasonable time frame.

All current quarry operators in Ontario must submit a detailed rehabilitation plan prior to creating a new or expanding an old quarry. Until recently, rehabilitation policies in Ontario recommended backfilling of exposed quarry walls to achieve uniform 3:1 slopes. This method is practical in situations where quarry walls are very unstable and where overburden for backfilling is readily available, but is impractical and costly where this is not the case. Under recent changes in government policy (B. Messershmidt, OMNR, pers. comm. 1998) backfilling to a 3:1 slope is no longer required if this can be justified in the context of the rehabilitation strategy for a given site.

Despite this policy shift, many operators continue to rehabilitate their lands to agricultural, commercial or conventional recreational (i.e. turf landscapes) uses as indicated in their original site plan, utilizing costly and labour intensive processes of backfilling, site grading and landscaping. These approaches continue to be selected in part because key personnel are not familiar with other alternatives.

The concept of approaching pit and quarry rehabilitation from a natural heritage perspective is not new, and has been under study for two decades in Great Britain. Beginning in 1978, J.G. Kelcey presented arguments that derelict land is a valuable resource and provided tremendous opportunities for wild recreation areas. In the context of otherwise homogenous agricultural landscape of Britain, the ecological value of disused limestone and chalk quarry habitat for nesting birds and mammals, and as refuges for rare and relict plant species, has been reported for many decades (Hepburn 1942,1955; Piggot and Walters 1954; Usher 1979). By the 1980's the recognition of disused pits as valuable natural landscape features became an incentive for conservation groups in Great Britain to purchase quarries and for government and industry to modify existing rehabilitation policies (Gunn et al. 1992).

Developing a Natural Heritage Approach

Current provincial planning policies in Ontario advocate a natural heritage approach for regional and municipal planning (OMNR 1997). Central tenets of this approach include the preservation of existing landscape physiography and core natural areas, reconnection of habitat fragments, and restoration of impacted lands to communities that occur naturally in the region. Insofar as quarry rehabilitation is concerned, we broadly define the natural heritage approach as the creation of self-sustaining, natural terrestrial and aquatic ecosystems that are compatible with existing site conditions and habitat types of the ecoregion. An example of natural heritage rehabilitation would include the creation of cliff and talus (rockfalls at the base of cliffs) habitats in quarries located adjacent to the Niagara Escarpment, or the creation of alvar or wetland habitats on quarry floors. The key elements of this approach involve a) developing an understanding of key physical attributes and processes of a site, b) recognizing ecologically appropriate natural habitat models or analogs for use in rehabilitation, and c) incorporating habitat components and suitable native species in re-vegetation and habitat reconstruction.

These approaches for limestone quarry rehabilitaion have been explored in Ontario and Great Britain. In Britain, the government-supported Limestone Research Group (LRG) has developed practical and cost-effective techniques for progressive rehabilitation of quarry margins since the mid-1980's. Using the structure and vegetation communities of natural limestone dalesides (similar to the cliffs of Ontario's Niagara Escarpment) as landscape models, they have developed a number of techniques and strategies that promote the replication of daleside landforms, including "restoration blasting" (Gunn et al. 1992), as outlined in the "Restoration Strategies" section of this paper.

In southern Ontario, there has been some research by the Ontario Ministry of Natural Resources (OMNR), Aggregate Producers Association of Ontario (APAO) and researchers at the Cliff Ecology Research Group (CERG) at the University of Guelph. This research, although less applied than the work conducted by LRG, has shown that limestone quarries in southern Ontario will develop natural plant communities comparable to those found on the Niagara Escarpment (Ursic et al. 1997), given adequate time and appropriate site conditions. The Niagara Escarpment, a UN Biosphere Reserve that extends from Manitoulin Island to Niagara Falls in Ontario, contains cliff faces and talus slopes that provide an excellent natural analog for quarry rehabilitation. Depending on site

hydrology, alvar (limestone pavements), mineral fens (calcareous wetlands) or shallow bedrock savannas could also be appropriate natural analogs for quarry floors.

Ursic *et al.* (1997) recorded 255 species of vascular plants, bryophytes (mosses) and lichens in their study of abandoned limestone quarries, indicating that these sites provide habitat for diverse species belonging to various life forms. However, what is more interesting is that the proportion of native to exotic vascular plant species was 60:40, a good ratio considering these sites are primarily colonized by ruderals (early successional species). Furthermore, much of the native vascular plant and bryophyte component also occurs naturally on Niagara Escarpment cliff faces, talus and tops (Table 1; Cox and Larson 1993; Larson et al. 1989). Examples of less common native Escarpment cliff vascular plant species recorded in abandoned quarries but not listed in Table 1 include *Asplenium trichomanes, Pellaea glabella, Cystopteris fragilis, Acer rubrum, Ulmus americana, and Aster ericoides.*

Table 1. The most frequent species/genera observed in a study of abandoned quarry faces, floors and tops in southern Ontario (from Ursic 1994). Percent relative abundance (% R.A.) shown. Species/genera also known to occur commonly on Niagara Escarpment cliff face (ú), cliff top and edge (+) and talus (*) (Cox and Larson 1993; Larson et al. 1989) are indicated.

Quarry Face Species	% R.A.	Quarry Floor Species	% R.A.	Quarry Top Species	% R.A.
Poa compressa. ú*	10.45	*Poa compressa.* ú*	12.28	*Poa compressa.* ú*	10.59
Hieracium spp.	4.99	*Hieracium* spp.	4.17	*Hieracium* spp.	6.51
Erigeron philadelphicus.	4.84	*Daucus carota*	4.17	*Daucus carota*	4.54
Verrucaria nigrescentoidea	4.57	*Solidago spp.**	3.98	*Solidago spp.**	4.38
Chrysanthemum leucanthemum	3.86	*Erigeron* spp.	3.62	*Trifolium campestre*	3.62
Thuja occidentalis+**	3.72	*Phragmites australis*	3.15	*Coronilla varia*	2.99
Solidago spp.*	3.52	*Thuja occidentalis*+**	2.67	*Plantago lanceolata*	2.39
*Taraxacum officinale**	3.26	*Agropyron repens*	2.29	*Bromus inermis*	2.28
Daucus carota	3.14	*Silene vulgaris*	2.20	*Agrostis gigantea**	2.11
Lepraria lobificans	2.87	*Cystopteris bulbifera**	2.04	*Phleum pratense*	2.09

Alvars or limestone pavements are naturally flat, open areas with little or no soil that contain some of the most diverse and rare vegetation in North America (Catling and Brownell 1995). These habitats are considered globally rare, but and are still largely unknown to the general public. Alvars provide ideal models for quarry floor rehabilitation since they require little or no soil and are capable of supporting species adapted to extremes in temperature and moisture. Unfortunately, there is very little available research on re-vegetation dynamics in alvars, although CERG is presently monitoring natural recolonization of a disturbed alvar habitat in Bruce Peninsula National Park in Ontario (Dr.U. Matthes-Sears, pers. comm. 1998).

Key Physical and Biological Factors in Quarry Rehabilitation

Recognition of the physical and biological parameters that influence vegetation succession is key to understanding the development of natural vegetation communities. Cliff and alvar habitats support many rare plant and wildlife species, in addition to predictable communities of shrubs, herbs, ferns, mosses and lichens (Davis 1951; Maser et al.

1979; Larson et al. 1989; Catling and Brownell 1995). Given that many older disused limestone quarries in Ontario support similar species, natural heritage rehabilitation efforts require consideration of factors that can affect recruitment and establishment of individual species and vegetation communities.

Plant Colonization

Quarrying exposes substrates previously not colonized by plants. Similar to surfaces exposed by large-scale natural disturbances such as deglaciation, these features give rise to primary successional processes. The resulting landscape is impoverished, lacking soils and nutrients, and is exposed to extreme temperature and moisture conditions. These conditions exclude or inhibit colonization by most species common to the surrounding landscape. Species adapted to these conditions typically include weedy ruderals and less common or rare native species which require habitats free of competition.

Short-term studies in disused quarries indicate that there is initially colonization by a fairly diverse plant community dominated by ruderals and limited colonization by longer-lived and/or unusual native species (Donelan and Thompson 1980; Jefferson and Usher 1987; Skaller 1977; Usher 1979; Bradshaw et al. 1982; Davis et al.1985). However, over a longer time frame many weedy ruderals (i.e. ox-eye daisy, *Chrysanthemum leucanthemum* and wild carrot, *Daucus carota*) are displaced by more desirable native species. Ursic et al. (1997) examined re-vegetation dynamics on the vertical cliff faces of 18 abandoned limestone quarries ranging from 17 to 92 years old. They found that vegetation species richness remains high and dominated by weedy ruderals for the first 55 to 70 years following abandonment, but as neighbouring trees (primarily eastern white cedar, *Thuja occidentalis*) seed into the quarry floor and begin to shade the walls, vegetation communities become less diverse and dominated by native, longer-lived species occurring naturally on cliffs of the Niagara Escarpment. Notably, higher diversity is not necessarily a good indicator of successful rehabilitation on these sites, and monitoring of species composition is critical in evaluating site progress.

Site Age and Size

Ursic et al. (1997) determined that time since quarry abandonment was the single most important environmental variable responsible for shaping species assemblages on abandoned quarry faces. However, this factor was inextricably related to other environmental variables such as quarry size, substrate stability and the development of a dense tree canopy on the quarry floor. This is not surprising, since older quarries have not only had longer to regenerate but were generally smaller and affected by less intensive blasting techniques than more recently mined sites. It is likely that site age and size have not emerged as significant in other studies because none of them examined abandoned quarries along a chronosequence extending for almost a century.

Aspect and Latitude

The aspect of quarry walls can influence plant species diversity and composition significantly since it regulates the amount of light a particular cliff face receives and also controls moisture availability. Risbeth (1948) observed that vegetation composition changed significantly between east and west facing limestone walls. Davis (1951) found no differences between cliffs with eastern and western exposures, but observed increased species abundance on south-facing as compared to north-facing cliffs. Ursic et al. (1997) found that south-facing cliffs consistently supported more species than north-facing walls, but that more northerly quarry sites appeared to develop forest cover on the floor and top more rapidly than sites in the south. While it is rarely possible to alter the design of the quarry to change the aspect and latitude of the exposed surfaces, it is important to consider these factors in selecting site-appropriate seed or plants.

Ledges

Ledges are a horizontal component to cliff faces where organic and mineral debris can accumulate, thus facilitating plant colonization. Since many species naturally colonize ledges it is not surprising that the presence of ledges tends to increase plant species richness. Ursic et al. (1997) found that, on average, quarry wall plots without ledges supported 12 species while plots with ledges supported 14 species. Ledge frequency has also been shown to be important in controlling which species become established on cliff faces (Davis 1951; Bunce 1968). It is possible to control the extent and size of ledges by modifying blasting methods. This has been studied in limestone quarries by LRG where they were able to create different ledge sizes and blast piles by using various combinations of shot-holes and vent-holes in charge zones (Gunn et al. 1992).

Substrate Stability

The stability of quarry edges, walls and floors is a critical factor determining how quickly re-vegetation occurs and what species are able to thrive in disused quarries, and is correlated to the type of geological formation being worked. Ursic et al. (1997) found that longer-lived woody species, mosses and lichens are excluded from unstable quarry walls. However, most common ruderal herbaceous species, including annuals and biennials, were capable of reaching maturity on even the most unstable quarry walls.

Improving substrate stability has been recognized by LRG as another key objective of their "restoration blasting" technique, for both ecological and safety reasons. They have been able to improve stability of cliff faces and rock piles at cliff bases with modern explosives by modifying detonation timing and sequence, as well as the number, pattern, depth and spacing of shot-holes (Gunn et al. 1992). More research remains to be done on methods for improving the stability of rock buttresses and headwalls.

Surrounding Vegetation

The presence of natural vegetation adjacent to quarry sites will obviously also have a significant impact on the rate and type of plant recruitment. Over the longer term, the density and height of vegetation adjacent to the quarry wall is one of the most important factors affecting the course of naturalization on a site since trees which become established on the quarry floor shade and shelter the quarry wall. The density and size of tree and shrub canopies on the quarry floor influences the quarry wall plant assemblages by limiting the amount of radiation that penetrates to the face, creating a cooler and moister environment. In southern Ontario, this favours native species typical of the Naigara Escarpment species, including *Thuja occidentalis, Lepraria lobificans, Cystopteris bulbifera, Cladonia cariosa* and *Marchantia polymorpha* (Ursic et al. 1997).

Restoration Opportunities and Strategies

Quarrying for limestone typically results in the formation of three distinct terrestrial landscape features or habitat types which can become naturally colonized by plants: quarry walls that can resemble natural escarpment cliff faces, floors that can resemble limestone pavements or alvars, and spoil banks or overburden piles that can resemble talus. Depending on the hydrological regime, wetland and aquatic systems may also occur. If the rehabilitation objective is to emulate natural habitats, then restoration strategies should attempt to facilitate or enhance natural colonization by introducing appropriate species to these habitats.

The key site factors described above provide a broad set of parameters for planning and implementing natural heritage rehabilitation in limestone quarries. Planning and design modifications must be initiated prior to quarry

excavation since the quarrying method utilized will have a direct bearing on the kinds of surfaces created. For example, if the rehabilitation objective is to re-create natural cliff face vegetation communities, then blasting regimes should be modified when approaching the limits of the working face in order to create a stable substrate with numerous ledges. Although unstable faces will stabilize over time due to substrate settling, soil deposition and weathering, the rehabilitation objective is usually to accelerate establishment of vegetation cover.
In Great Britain, the LRG has developed a technique called "restoration blasting" designed to replicate natural landforms of the local limestone dalesides while also safely and effectively extracting limestone materials (Gunn et al. 1992). This technique reduces final face heights by constructing scree blast piles, covering the quarry face to varying heights by altering scree pile size and fragmentation, ensuring the stability of blast piles by retaining rock steps, creating cut-backs on the face, and producing rock buttresses and head walls of varying heights. Studies to date indicate that within 3 to 10 years, vegetation establishes itself more readily and develops a more consistent cover than in quarries blasted using conventional methods (Gunn et al. 1992; Wheater and Cullen 1997) although vegetative cover and species composition is not the same as that found on natural dalesides.

In addition to landform replication, LRG has experimented with a number of techniques for speeding up vegetation establishment by native daleside species. Recognizing that topsoil is not an economic or practical seedbed for this habitat, they have used existing site materials for cover such as chippings (crushed limestone), and unsterile sand mixed with peat. Hydroseeding in conjunction with pit planting of trees into the scree (equivalent to Ontario's Escarpment talus) has been quite effective. Use of mulch and peat during seedling establishment has also been helpful, but more important has been the selection of native species that are typical of dalesides and disused quarries and naturally adapted to the extant conditions (Gunn et al. 1992).

Modified blasting technologies could be used to replicate Escarpment cliff faces and talus. The use of benching and selective blasting followed by seeding (drilling, broadcasting, hydroseeding or slurry sprayed from the top of the quarry) can also help naturalize a quarry progressively (Coppin and Bradshaw 1982). Species selection must be based on an understanding of the natural communities that will form on the habitat being replicated.

Although no studies have been published to date on creation of alvar habitats, Jefferson and Usher (1987) found that many undesirable species were colonizing the floors of 3 disused chalk quarries. Consequently, they recommended a rotational scraping of small areas to encourage establishment of a rare native species-rich community and to prevent establishment of invasive species. Although it goes against "common sense" to remove topsoil to encourage plant establishment and growth, the species adapted to these habitats thrive with fewer nutrients and less competition from other plants.

In view of the findings of Ursic et al. (1997) regarding surrounding vegetation, another potentially effective strategy would be to try to maintain and/or establish tree cover with eastern white cedars at the top and base of the quarry face. This will encourage natural colonization by long-lived cliff-dwelling species, and exclude weedy ruderals. In locations where appropriate natural vegetation communities surround the quarry site, less introduction of planted materials will be required, but since trees grow slowly on these sites (Matthes-Sears and Larson 1995; Kelly et al. 1992) it may be advantageous to plant some seedlings as well.

Where woodlots or other natural habitats will be destroyed as a result of quarry operations, there are opportunities for salvage of existing biological material. This strategy will likely be most effective on quarry tops where this material can be used to create a screen during excavation and then blend into the rest of the site afterwards. While

it may be impractical to move large trees, salvage of soil seed bank and propagules can be conducted effectively without double-handling if staging of quarry operations includes plans for direct transfer of materials from donor to receptor sites. Temporary storage of topsoil can also be effective as long as it is handled properly and not stored for too long (Tacey and Glossop 1980). Herbs and shrubs can also be moved successfully if this is done during the proper season (usually spring) and by contractors who ensure that plant root systems are kept intact with their associated soil and that the plants are adequately watered during and after transplant (Munro 1994). Consideration must also be given to ensuring that the donor and receptor sites are similar in topography, hydrology and aspect in order that the plants will be able to adapt.

Summary & Discussion

The benefits of allowing natural processes to rehabilitate the walls of abandoned limestone quarries include the recruitment of an uncommon but native component of biodiversity, a reduced initial cost, and a reduced long-term maintenance cost. However, the 70 to 100 year timeframe for natural recolonization is probably not acceptable in most cases, and so strategies to accelerate succession on quarry walls and floors are required. Key strategies include use of blasting methods that create more stable faces with ledges akin to those found on natural escarpments, various seeding techniques, direct planting, and the creation of suitable tree canopies on quarry floors and tops.

Although this paper has emphasized general approaches to and strategies for natural heritage after-uses for limestone quarries, it is important to note that each site will have a unique set of conditions to consider. Even among limestone quarries in southern Ontario there is variation in geological formations that directly influences the stability of the substrate and ledge frequency. For example, the Amabel and Guelph geological formations contain massively bedded dolostones, commonly used for building and armour stone (Derry et al. 1989), that provide solid bedding planes for the establishment of long lived species. Factors such as the aspect of the quarry faces and the presence and quantity of water on the quarry floor will also affect the types of vegetation and wildlife that can colonize and the kind of restoration strategy that will be required.

It is critical that realistic time frames be set for the natural heritage rehabilitation of sites. Even with the use of restoration blasting, seedbank salvage and co-plantings the rehabilitation process on these sites is slow by typical standards since only slow-growing species survive on these sites. However, given the time frames of most current quarry operations (50+ years in some cases), rehabilitation can begin to regenerate while operations are ongoing, so that by the time excavation is complete parts of the quarry will be in the advanced stages of rehabilitation.

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Management of Abandoned Aggregate Properties Program

Christopher P. McGuckin

Management of Abandoned Aggregate Properties Program
Aggregate Producers' Association of Ontario

ABSTRACT

Abandoned aggregate pits and quarries dot the Ontario landscape and are industrial remnants of its historical settlement. Many of these sites were situated adjacent to built areas and have been rehabilitated to housing and parks as development incorporated them. Others were situated in more remote areas in the rural landscape and have naturalized to provide habitat for aquatic and terrestrial wildlife. However, many are unproductive, under-utilized sites that are incompatible with their surrounding landscape and may represent community safety hazards and visual scars in need of rehabilitation.

The Aggregate Producers' Association of Ontario has entered into a partnership with the Ontario Aggregate Resources Corporation to deliver a program of rehabilitating abandoned aggregate properties in Ontario and conduct research into pit and quarry rehabilitation techniques. Funding for the Management of Abandoned Aggregate Properties Program (MAAP) comes from current licensed aggregate producers in the province, who pay an annual production fee of one-half cent for every tonne of aggregate sold. These funds are used to rehabilitate aggregate sites abandoned prior to December 31, 1989.

This paper will provide an overview of the MAAP program activities in 1997-1998. In its first season, MAAP successfully rehabilitated fourteen abandoned aggregate properties in Ontario, representing more than 20 hectares of disturbed landscape returned to productive agricultural land, pasture, natural area, and wetland. MAAP has targeted twelve abandoned aggregate properties for rehabilitation in 1998, and is pursuing several partnerships with public agencies and community groups. In addition, MAAP will be supporting research into innovative techniques for the rehabilitation of aggregate properties.

Background:

Abandoned aggregate pits and quarries dot the Ontario landscape and are industrial remnants of its historical settlement. The Ontario Ministry of Natural Resources (OMNR) has estimated that there are over 7,000 of these sites across the province[1]. They range in size from several thousand square metres to several hundred hectares and their locations vary from urban to near-urban areas, and the rural landscape. The aggregate from these sites was used for many purposes, but mainly to build our towns and the local, regional and provincial roads that connect them.

At the time most of the material was extracted from these sites (early 1900's – 1971), there was no legislation in the province requiring owners or operators to rehabilitate these sites once they were finished. Most were simply abandoned. Consequently, today these sites exist in varying states of rehabilitation. Many of these sites were historically situated close to built areas for economic reasons and have long since been rehabilitated to

[1] This number is derived from the approximate total number of site inventory files transferred from OMNR to the Aggregate Producers' Association of Ontario in June, 1997.

subdivisions or parks as development spread and incorporated them. An untrained eye would have a difficult time distinguishing many of these sites as old aggregate properties. Examples include Willowvale Park ("Christie Pits") and Smythe Park in the City of Toronto, Norton Park in Brampton, and River Oaks in Waterloo.

Other sites, primarily used for aggregates for road construction, were situated in more remote areas in the rural landscape and have been left to naturalize on their own providing habitat for aquatic and terrestrial wildlife. Examples include the former clay pits in Wainfleet which are part of the class 1 wetland complex in the Wainfleet Wetlands Conservation Area, and a former quarry in Stoney Creek known as 87 Acres Park which is designated as an ESA by the Hamilton Region Conservation Authority. Several large sites support recreational activities such as bird watching, fishing and swimming. Examples include Professor's Lake in Brampton, and St. Mary's quarry in St. Mary's. Some sites contain rare or interesting features and are used for educational purposes. Examples include the Wainfleet Quarry, which contains regionally rare fossils, and several abandoned quarries on the Niagara Escarpment where century old cedar trees are growing.

However, many abandoned aggregate properties are unproductive, under-utilized sites that are incompatible with their surrounding landscape and may represent community safety hazards and visual scars. To many people, these are the sites most often associated with abandoned aggregate pits and quarries since the well rehabilitated sites blend so easily into the surrounding landscape. Some of these abandoned sites are used as storage for old rusting farm equipment and vehicles, scrap metal, wood, and construction materials. Others are large weedy patches in the middle of agricultural fields that no longer possess adequate soil structure and nutrients, or are too steep, to be put into crop production or pastured. Many are sites that have naturalized on their own, but possess a simple ecosystem structure due to poor habitat quality and lack of species diversity resulting from the lack of biophysical resources required to support complex systems. These sites require active rehabilitation efforts to return the land to a higher end use that is compatible with the surrounding landscape.

Management of Abandoned Aggregate Properties Program (MAAP):

The Aggregate Producers' Association of Ontario (APAO), an industry association representing aggregate producers in the province since 1957, has entered into a partnership with the Ontario Aggregate Resources Corporation to deliver a program of rehabilitating abandoned aggregate properties in Ontario and conduct research into pit and quarry rehabilitation techniques. The program is known as the Management of Abandoned Aggregate Properties Program (MAAP), and is the successor of the abandoned pit and quarry rehabilitation fund formerly administered by the OMNR.

Funding for MAAP comes from current licensed aggregate producers in the province, who pay an annual production fee of one-half cent for every tonne of aggregate sold. Based on production, the MAAP annual budget varies from $400,000.00 - $650,000.00. These funds are used to rehabilitate abandoned aggregate sites, undertake research initiatives on rehabilitation techniques, and administer the fund.

The MAAP program only deals with "abandoned" aggregate properties, defined in the **Aggregate Resources Act** as "pits and quarries for which a licence or permit was never in force at any time after December 31, 1989". The MAAP program does not pay for the rehabilitation of active pits and quarries, or for properties that have had their licences or permits revoked due to non-compliance or other reasons. The owners or operators of these properties are responsible for the rehabilitation of these sites. The program also does not pay for the

rehabilitation of abandoned aggregate sites in non-designated areas in the province where the **Aggregate Resources Act** does not apply.

The goals of the MAAP program are:

- To rehabilitate abandoned pits and quarries in the province of Ontario; and
- To encourage and support research pertaining to the rehabilitation of abandoned aggregate properties in the province of Ontario

The broader objectives of the program are:

- To successfully rehabilitate known abandoned pits and quarries using a variety of reclamation methods and techniques;
- To monitor selected rehabilitation sites and record their progress;
- To document rehabilitation methods and techniques used and monitor their success;
- To provide support and funding for research pertaining to pit and quarry rehabilitation;
- To provide support and funding for research pertaining to aggregate resource management and its connection to progressive rehabilitation techniques; and
- To encourage partnership development in projects completed by the program.

Inventory and Assessment of Candidate Sites for Rehabilitation:

The OMNR has completed approximately 7,000 inventories and assessments of abandoned aggregate properties across the province. Each of these sites was given a priority ranking based on several site factors, including size, safety hazards, accessibility, visibility, aesthetics, and environmental and economic factors. In assessing candidate sites for rehabilitation, MAAP utilizes these inventories and ongoing requests from interested landowners to determine a number of geographic areas to target each year and focus the program's resources in an equitable, cost-efficient manner. MAAP makes a conscious effort to select different geographic areas each year to maximize the fair distribution of rehabilitation funds across the province. Generally, 4 – 5 geographic areas are selected annually.

Landowner co-operation is an integral component of site selection. Landowner interest continues to increase as more people learn about the MAAP program through promotion and signage. MAAP has received requests from many landowners whose properties were never inventoried by OMNR, indicating that the estimate of abandoned aggregate properties in the province is probably low. In all cases, MAAP performs a site inventory and assessment on all candidate sites to update the original OMNR inventory or add the new sites to a database. All sites inventories and assessments are presently being organized in a computer database of all abandoned aggregate properties that will track rehabilitation efforts. MAAP generally visits up to fifty candidate sites annually, before selecting which sites will be rehabilitated through the program in each year.

Rehabilitation of Abandoned Aggregate Properties:

Having selected a number of candidate sites in each geographic area, MAAP compiles background information on each site to ascertain landowner and property information, zoning designations and land use of the site and surrounding areas, and more detailed information on the existing conditions and resources of the site. MAAP then contacts landowners to determine if they are interested in participating in the program. If they are, MAAP

prepares an overall rehabilitation plan with input from the landowners. It is worth noting that many landowners that have been contacted are not interested in having MAAP rehabilitate their abandoned sites. These landowners may be using their sites for an alternative use (i.e., storage of equipment), or express a desire to perhaps re-open the pit with a wayside permit, or simply do not trust others "fixing up" their land.

A proposed scope of work and budget is prepared by MAAP for each project and is submitted for approval by the Ontario Aggregate Resources Corporation. Upon approval, MAAP prepares a detailed rehabilitation plan with design sketches for approval by the landowners. Upon acceptance, landowners sign a consent form permitting MAAP to tender the work required to carry out the rehabilitation. MAAP does not provide lump sum payments to landowners to rehabilitate their properties on their own or by a third party. MAAP also does not pay for de facto rehabilitation of abandoned aggregate properties.

In order to properly manage the scope of work, project costs, quality of work and contractor performance, MAAP administers all construction contracts through a tendering process. MAAP prepares detailed tender documents complete with contract requirements, design sketches and project specifications for each project. Contracts are awarded through a public tendering process which includes a mandatory pre-bid site meeting so that all contractors bidding on the job are familiar with the site and the contractual obligations. MAAP staff provide the contract administration for each project, including site supervision during construction, certifying payment and contract performance, and conducting warranty inspections.

1992-1996 Rehabilitation Projects:

According to information provided by OMNR to the APAO, the OMNR rehabilitated 43 abandoned aggregate sites across the province between 1992-1996, of which 95% were abandoned aggregate pits and 5% (2 sites) were abandoned quarries. From the information provided, it is difficult to ascertain detailed project expenditures, specific details on the scope of work, the actual size of the site rehabilitated, and contractual obligations for many of the projects. Additional sites may have been rehabilitated under the former abandoned pits and quarries rehabilitation fund during this time period, for which we do not have any data.

Based on the data provided by the OMNR, a total of 68.29 hectares were rehabilitated between 1992-1996, at a total cost of $634,814.98, resulting in an average rehabilitation cost of $9,295.87 per hectare. The average size of site rehabilitated was approximately 1.5 hectares. Although details of the rehabilitation work at each site are not well documented, a breakdown of the type of rehabilitation that occurred is indicated in Figure 1. Nearly 50% of the total land area rehabilitated was returned to natural area (dry land), and more than 25% was returned to agricultural pasture land. Very little of the rehabilitation work involved the creation of recreational areas (less than 5%).

1997 Rehabilitation Projects:

In its first year, the MAAP program rehabilitated fourteen abandoned aggregate properties across the province of Ontario. These sites, and five others, were selected and approved for rehabilitation by the OMNR in 1996. However, in 1996 no sites were rehabilitated as the responsibility for administration of the abandoned pits and quarries rehabilitation fund began to shift from OMNR to the APAO. The rehabilitation of these nineteen sites became a condition of the final transfer of the program to the APAO in June, 1997.

Of the nineteen sites earmarked for rehabilitation, five sites were dropped for the following reasons:

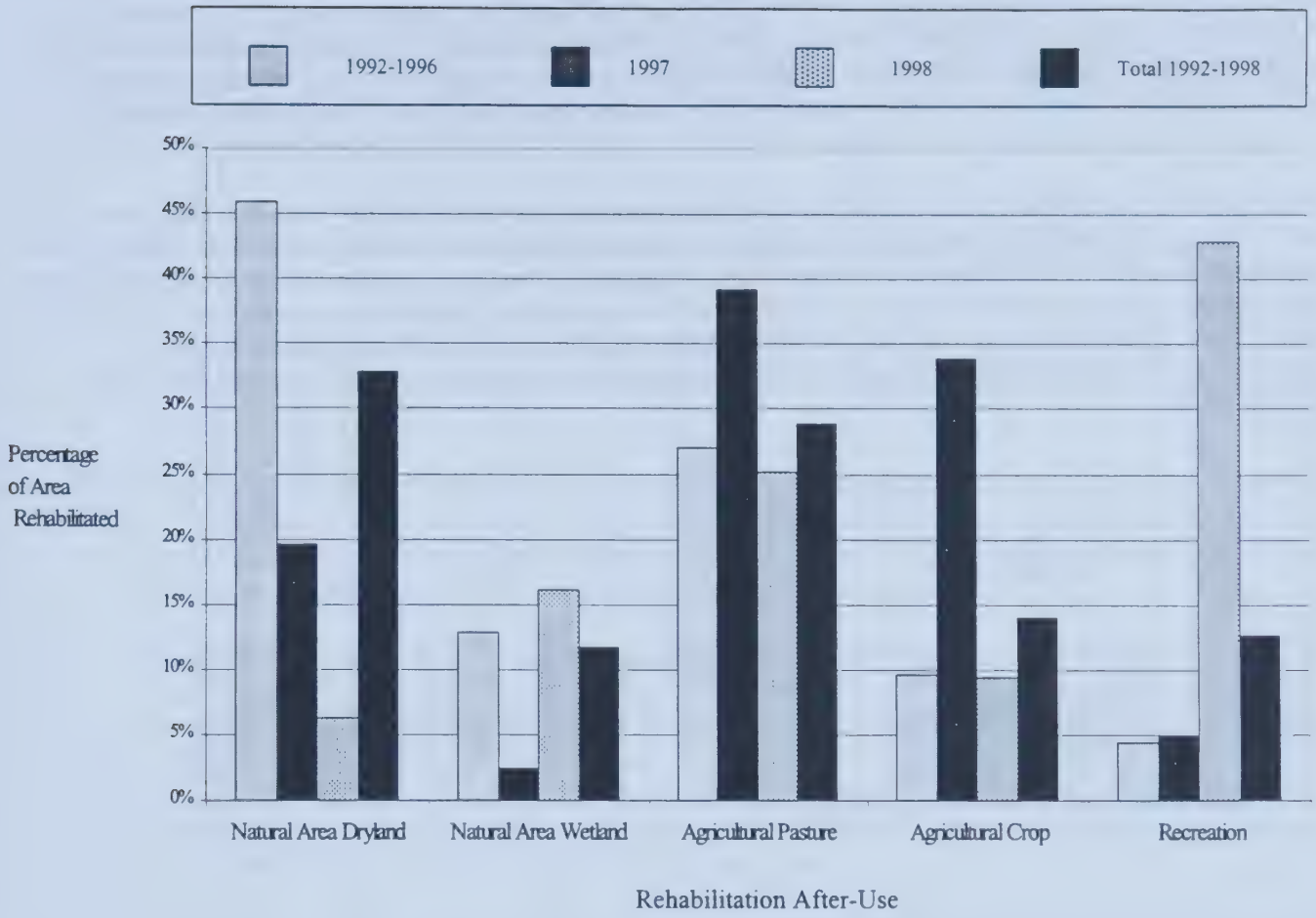


Figure 1. Rehabilitation After-Use as Percentage of Total Area Rehabilitated Through the Abandoned Pit and Quarry Rehabilitation Fund and MAAP Program

- Two of the landowners were not interested in having their sites rehabilitated, although one requested his property be included in 1998, only to change his mind again;
- One landowner was not committed to the rehabilitation of his property, and upon further site analysis, MAAP discovered an ownership discrepancy and the site was actually in a remote land-locked location that was rehabilitating naturally on its own, so a decision was made to leave it alone and monitor its rehabilitation; and
- Two of the sites were tendered, but postponed until 1998, because in one case all of the tenders received were too high, and in the other, only one legitimate tender was received.

All of the fourteen sites rehabilitated through the MAAP program in 1997 were abandoned aggregate pits. Generally, the projects took place in the following geographic areas: Owen Sound region (4 sites); Sudbury region (2 sites); Peterborough region (4 sites); Southwestern Ontario region (3 sites); and Ottawa region (1 site).

A total of 20.40 hectares were rehabilitated at a total cost of $489,808.53, resulting in an average rehabilitation cost of $24,010.22 per hectare. The average size of area rehabilitated was approximately 1.5 hectares. A breakdown of the type of rehabilitation that occurred is indicated in Figure 1. Over 70% of the land area rehabilitated was returned to agricultural use, nearly evenly split between crop production and pasture land. Very little of the rehabilitation work consisted of the creation of wetland habitat (2.45%), or recreation (4.90%).

Figure 2 shows a breakdown of the rehabilitation costs by activity for all of the 1997 projects. The greatest cost was for earthmoving (29%), which included site grading, excavating and backfilling work. Fine grading accounted for 26% of rehabilitation costs, and included stripping, stockpiling and spreading of existing topsoil, and where necessary, the importation of topsoil to achieve a minimum 50mm depth of topsoil over all disturbed areas. Five of the thirteen projects required the importation of topsoil to achieve the minimum depth requirement. Finally, seeding accounted for 13% of costs, and planting of native trees and shrubs 11% of project costs.

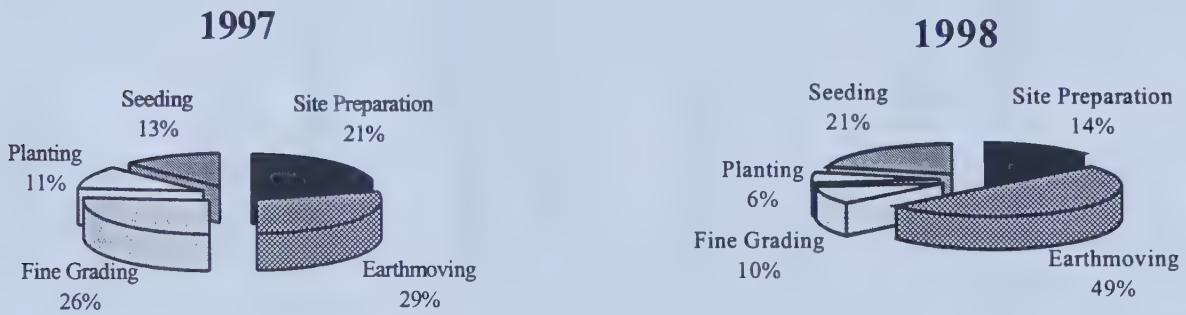


Figure 2. Rehabilitation Costs by Activity for 1997 and 1998 to date (July, 1998)

All fourteen rehabilitation projects were completed on time and under budget. All projects, except one, were tendered in late August/early September, and all work was completed by mid-October. Four of the sites were not seeded until the spring of 1998, due to weather conditions in the fall. Figure 3 shows a sequence of pictures documenting the rehabilitation of an abandoned gravel pit in the Peterborough area to pasture land.



Figure 3. Before, During and After Pictures of Rehabilitation of Abandoned Aggregate Property in Peterborough, Ontario in 1997 Under the MAAP Program

1998 Rehabilitation Projects:

MAAP has selected 12 abandoned aggregate sites for rehabilitation in 1998. The following geographic areas were targeted: Greater Toronto Area, including Caledon (2 sites) and Uxbridge (2 sites); Niagara Peninsula region, including Wainfleet (1 site) and Stoney Creek (1 site); London region (2 sites); Barrie region (1 site); and Belleville-Kingston region (3 sites).

MAAP made a conscious effort to meet several of the program's broader objectives in selecting sites for rehabilitation in 1998, including:

- Geographic Areas – New areas were selected to try and fill in some of the gaps between existing sites that had been rehabilitated in the past under the abandoned pits and quarry rehabilitation fund and MAAP program.

- Quarries – Three of the twelve sites (25%), selected for rehabilitation were quarries. Based on the fact that only two abandoned quarry sites have been rehabilitated since the abandoned pit and quarry rehabilitation fund began rehabilitating sites in 1992, it was felt that a greater effort needed to be made to demonstrate a variety of reclamation techniques in quarries.

- Partnerships – In an effort to build partnerships with agencies and community groups interested in rehabilitating abandoned pits and quarries, MAAP has formed active partnerships on five of the twelve rehabilitation projects. Partners include local municipalities in Stoney Creek and Middlesex Centre; a conservation authority and naturalist group in Wainfleet; a school board in Belleville; and community recreation groups in Barrie and Middlesex Centre. These partners have assisted in the preparation of designs, drawings, and the provision of in-kind contributions in the form of labour, equipment and materials (i.e., topsoil, habitat structures).

- Rehabilitation After-Use – An attempt was made to select sites that were suitable for rehabilitation to uses that were representatively small in previous years. Specifically, several sites were chosen where rehabilitation to natural area wetlands and recreation were suitable.

A total of approximately 23.85 hectares of abandoned aggregate property will be rehabilitated in 1998. The average size of area rehabilitated at each site will be approximately 2.0 hectares. A breakdown of the type of rehabilitation that will occur is indicated in Figure 1. There are some major differences in the type of rehabilitation after-use between 1997 and that planned for 1998. Contrary to rehabilitation efforts in 1997, agricultural after use will only account for approximately 35% of the total land area rehabilitated, whereas the creation of recreational lands will account for over 40% and wetland habitat will account for nearly 20% of the total area rehabilitated.

As of July 1998, five of the twelve rehabilitation projects have been tendered and four have been completed. The four rehabilitated sites represent 6.25 hectares of land to be rehabilitated (26% of the total), at a total tendered cost of $85,977.13, resulting in an average rehabilitation cost of $13,756.34 per hectare. The average size of area rehabilitated was 1.5 hectares. Figure 2 shows a breakdown of the rehabilitation cost by activity for the four rehabilitated sites. It is difficult to compare this data with 1997 information because it includes less than half of the total projects and these projects were mainly earthmoving projects involving regrading work. Additionally, one of the sites was particularly large (3.0 hectares).

Nonetheless, the rehabilitation costs thus far are quite different than 1997. For example, earthworks accounts for approximately one-half of all project costs, versus the nearly one-third it did in 1997. The proportion of cost allocated to fine grading is significantly less (10%), than in 1997, due in large part to the fact that the majority of sites rehabilitated did not require the importation of topsoil. Finally, seeding and planting work still consists of approximately 25% of all project costs, the same amount spent on these two items in 1997, although in different proportions.

The remaining 7 projects will be tendered in the late summer and rehabilitation work will occur in September-October, 1998. Several of these projects will focus on enhancement of existing features, rather than simply regrading slopes, seeding and planting. For example, three of the rehabilitation projects will involve the creation of wetland habitat, including the erection of a bald eagle nesting platform at one of the sites. Two of these projects will occur within quarries. At these sites, a conscious decision was made in consultation with the landowners to direct rehabilitation efforts toward the creation of habitat, rather than blasting or backfilling slopes. The existing quarry walls have been recognized as significant features of the sites, contributing to the overall aesthetic quality, containing information on the geology and history of the area, and providing quality habitat for snakes and other wildlife.

Nearly half of the 1998 rehabilitation projects will be carried out in "partnership" with other agencies and groups. Partnership development is very important in developing community and agency relations and building trust, and also makes the most sense from a cost-efficiency perspective. Partners contribute in many ways, including the preparation of design drawings, contributions in-kind of equipment, materials and labour for the project, and help in publicizing the results. These projects also tend to be the most exciting because they are often broader in scope and provide for innovative solutions and techniques. However, these partnerships also pose the greatest challenge in getting projects constructed within the relatively short time frame in which MAAP annually operates. The necessary consultation and approvals required to tender and construct these projects tend to be more complicated than the requirements to rehabilitate abandoned aggregate properties on private land.

Research and Monitoring:

The MAAP program also supports and provides funding for research pertaining to aggregate pit and quarry rehabilitation. In 1997, the MAAP program continued to fund a research study initiated through the former abandoned pit and quarry rehabilitation fund that is investigating the biodiversity of abandoned aggregate sites on the Oak Ridges Moraine. This research is examining existing biodiversity on the moraine, and will analyze the relationship between the extraction and rehabilitation techniques used and the resulting natural communities over time. The study will also suggest methods to be used in developing a predictive model for naturalizing aggregate sites on the Oak Ridges Moraine. Study results are expected in the fall of 1998.

The MAAP program has also entered into a research partnership with the Federal Department of Fisheries and Oceans (DFO), to investigate the affects of modifying aquatic habitat on fish populations in abandoned aggregate pits and quarries. The intent of the study is to identify aquatic reclamation options that produce clear biological benefits. This study will be carried out over a six year time frame, commencing in 1998. It will investigate the impact habitat manipulation has on fish populations in both pits and quarries in sites across Ontario, including Belleville, the Oak Ridges Moraine and Stoney Creek. The first two years of the study will involve marking and recapturing fish to determine their age, abundance and growth patterns. Modifications to aquatic habitat will occur in years three and four, and may consist of enhancing littoral zone habitat through gradient manipulation, the introduction of woody debris and gravel substrate, and/or wetland creation. The impacts of the habitat modifications on the fish populations will be assessed in years five and six. A comparison

of parameters before and after the habitat modifications should reveal rehabilitation techniques that contribute to the establishment of biologically productive water bodies.

In addition to these studies, the OMNR has supported several research studies through the former abandoned pits and quarries rehabilitation fund. These include prairie grass establishment in southwestern Ontario, the use of pulp and paper mill sludge or biosolids as an alternative to topsoil in the rehabilitation of abandoned aggregate pits in eastern Ontario, and the study of revegetation dynamics of cliff faces in abandoned limestone quarries.

The MAAP program is also monitoring the rehabilitation of all sites it rehabilitates in order to document what techniques were successful and which ones were not. For example, MAAP is monitoring the overall growth of different seed mixes applied to different sites, and at one site, is monitoring seed establishment with and without mulch. Together with the project cost data, this information is critical in assessing and identifying the most appropriate and cost-effective techniques for rehabilitating abandoned pits and quarries, and will assist in directing future efforts.

Summary:

In the six and one-half year period between 1992 and July, 1998, a total of 61 abandoned aggregate sites were rehabilitated across the province through the abandoned pit and quarry rehabilitation fund and MAAP program. These sites were distributed in 23 of the 35 regions/counties designated under the **Aggregate Resources Act** (Table 1). By the end of 1998, nearly 75% of all designated areas will have had at least one, and some as high as seven, abandoned aggregate properties rehabilitated through the program.

Region/County	Number of Projects	Region/County	Number of Projects
Algoma	0	Lennox & Addington	0
Brant	0	Middlesex	1
Bruce	5	Niagara*	0
Dufferin	2	Northumberland	1
Durham	2	Ottawa-Carleton	2
Elgin*	0	Oxford	0
Essex	0	Peel	3
Frontenac*	0	Perth	2
Grey	4	Peterborough	2
Haldimand-Norfolk	5	Prescott & Russell	0
Halton	2	Simcoe	6
Hamilton-Wentworth	1	Stormont, Dundas & Glengarry	1
Hastings	4	Sudbury	5
Huron	2	Victoria	5
Kent	2	Waterloo	2
Lambton	0	Wellington	1
Lanark	0	York	1
Leeds & Grenville	0	**TOTAL**	**61**

*Regions/Counties with rehabilitation projects to be completed in 1998

Table 1. Distribution of Abandoned Aggregate Properties Rehabilitated Through the Abandoned Pit and Quarry Rehabilitation Fund and MAAP Program

A total of 94.94 hectares have been rehabilitated at a total cost of $1, 210,600.64, resulting in an average rehabilitation cost of $12,751.22 per hectare (Table 2). The average size of area rehabilitated was approximately 1.5 hectares. A breakdown of the type of rehabilitation after-use for all sites, including the remaining 8 projects to be tendered in the fall 1998, is included in Figure 1. The main type of rehabilitation work is returning abandoned aggregate sites to natural dry land areas (33%), followed by the creation of agricultural pasture land (29%). This is probably a direct result of the locations of the majority of abandoned aggregate sites. Most sites are located in the rural environment, either surrounded by farm fields or adjacent to wooded or natural areas. Rehabilitation to natural wetland area, agricultural crop land or recreation are all similar (12-14%).

Year	# of Rehabilitation Projects	Area Rehabilitated (ha)	Total Cost	Analysis		
				Average Rehabilitation Cost/ha	Average Rehabilitation Cost/Project	Average Size of Area Rehabilitated (ha)
1992	2	3.1	$10,0000.00	$3,225.81	$5,000.00	1.55
1993	2	2.53	$81,157.33	$32,078.00	$40,578.67	1.26
1994	14	23.52	$175,975.66	$7,481.96	$12,569.69	1.68
1995	25	39.14	$367,681.99	$9,394.00	$14,707.28	1.56
1996*	0	0.00	$0.00	$0.00	$0.00	0.00
1997	14	20.40	$489,808.53	$24,010.22	$34,986.32	1.46
1998**	4	6.25	$85,977.13	$13,756.34	$21,494.28	1.56
TOTAL	**61**	**94.94**	**$1,210,600.64**	**$12,751.22**	**$19,845.91**	**1.56**

* No sites rehabilitated due to transfer of responsibility for program from OMNR to APAO

** Completed as of July, 1998

Table 2. Summary of Abandoned Pit and Quarry Rehabilitation Projects (1992 – July, 1998)

Despite the higher average rehabilitation cost per hectare in 1997, the rehabilitation costs so far in 1998 ($13,076.02 per hectare) are consistent with the overall average for all 61 sites completed ($12,751.22 per hectare). Despite the uncertainty of the type of rehabilitation work carried out in the 43 projects completed by the OMNR, these values provide us with a reasonably accurate per hectare cost for the rehabilitation of abandoned aggregate pits. Due to the very low number of quarries rehabilitated (2 out of 61 sites), caution should be used in translating this number to quarry rehabilitation, especially since different techniques may be required.

Based on all of the program activities to date, the MAAP program will aim to achieve the following recommendations:

- Quarries – By the end of 1998, only 7% of all abandoned aggregate sites rehabilitated through the OMNR and MAAP program will be abandoned quarries. A greater effort must be made in future site selection to include abandoned quarries in order to learn more about appropriate rehabilitation techniques and gain a better understanding of the associated rehabilitation costs.

- Larger Sites – The average size of abandoned aggregate site rehabilitated is 1.5 hectares. A greater effort should be made to select several larger size sites (> 3.0 hectares), in order to demonstrate ability and determine if cost-savings can be realized in the average rehabilitation cost per hectare when rehabilitating large sites.

- Rehabilitation After-Use – The MAAP program has begun to correct the inequity in rehabilitation after use of abandoned sites rehabilitated through the program. However, a stronger effort needs to be made to select more sites that will be returned to natural wet area, agricultural crop land and recreation in order to gain a better understanding of appropriate techniques and the cost of doing this sort of rehabilitation work.

- Geographic Areas – The MAAP program will continue to target the remaining 25% of designated areas of the province that have yet to have abandoned aggregate properties rehabilitated through the program.

- Documentation – Continuing on the first two years of the MAAP program, a better effort needs to be made to document the entire rehabilitation process, including the tender process, contract obligations, specifications and performance of the work in order to produce accurate information on successful rehabilitation techniques and costs. Together with the results of research initiatives, this information needs to be widely disseminated to practitioners involved in rehabilitating aggregate pits and quarries.

AN INNOVATIVE APPROACH TO WASTE SITE MANAGEMENT, TREATMENT, AND REHABILITATION

Mark Madison and Alicia Lanier

CH2M HILL, Portland, Oregon

and

Chris Shrive

CH2M Gore & Storrie Limited, Waterloo, Ontario

ABSTRACT

The innovative use of poplar trees at landfills and other waste sites to improve final closure cover caps and to treat and monitor leachate and stormwater runoff offers significant cost and management advantages with the potential for restoration and the commencement of ecological blending with surrounding landscapes. This paper describes the basic concepts for using poplar tree technologies and compares the poplar tree systems with the more common and ecologically sterile conventional approaches, such as the synthetic membrane cover cap and land application of leachate on grass crops. The paper also discusses where the poplar tree systems are feasible, the main elements of their implementation, and the potential cost savings that can be realized, together with the prime elements of their use as "conditioners" in longer term restoration endeavours. Current industrial and municipal applications and examples of the technology from Ontario and North America are described.

Introduction

Poplar tree systems are currently operated at landfills as final closure cover caps and to manage leachate and stormwater runoff. The Oregon Department of Environmental Quality (DEQ), the Virginia DEQ, and the Iowa Department of Natural Resources have approved these systems. The Virginia DEQ has commissioned studies to establish regulations for this promising new technology. Poplar tree systems are attracting interest among landfill operators because they are manageable, effective, environmentally friendly, and economical.

The essential components of the systems are, of course, the hybrid poplar trees themselves – one of the fastest growing trees in North America. Planted at high densities, they produce more biomass per year than any other perennial. Consequently, they consume more water and nutrients than any other kind of crop. They root deeply and tolerate poor soil and water quality conditions; therefore, they are able to flourish in adverse environments, such as might be encountered at landfill sites.

Since 1989, CH2M HILL has been a pioneer in the research, permitting, design, installation, management, and monitoring of poplar tree systems. The two types of systems described in this paper are a poplar tree landfill cover cap and a poplar tree buffer treatment system suitable for leachate or stormwater management.

Cover Caps

The poplar tree cap consists of a dense stand of poplar trees, a ground cover of grass or clover, and an associated soil system – all of which together can collect, store, and consume natural precipitation at the site. The principal concepts and design factors are illustrated in Figure 1. The critical water balance analysis that is performed as part of each design is represented by the formula: Accumulation = Input – Output ± Reactions. The standard inputs, outputs, and reactions are also shown in the figure.

At present, most landfill operators construct final closure caps out of conventional, low-permeability synthetic membranes with a thin topping layer of soil and vegetation. The cap is designed to minimize water infiltration into the refuse, prevent erosion, and protect human health and the environment. A poplar tree system can do these things cheaper with additional benefits.

Unlike synthetic membranes that deflect precipitation from the site, the poplar tree system intercepts and uses water for plant growth. Water is stored in the soil pores of the thick soil cap and removed by the tree roots. During the growing season, all precipitation evaporates or transpires from the site, dehydrating the soil. During the dormant period, soil pores in the tree root zones are recharged by storing precipitation.

The trees and grass are planted on the landfill contour for erosion control. During the first year, surface-applied compost mulch or shredded yard debris also stabilize the soil. With maturity, the trees' thick root systems hold the soil together and the canopy of leaves shields the ground from raindrop impacts and consequent erosion. When the leaves fall in the autumn, they contribute to the mulch at the site and the overall water-holding capacity of the system. A rougher ground surface develops and water flows more slowly down the slopes. With time, the cap becomes a mature forest with little wind or water erosion.

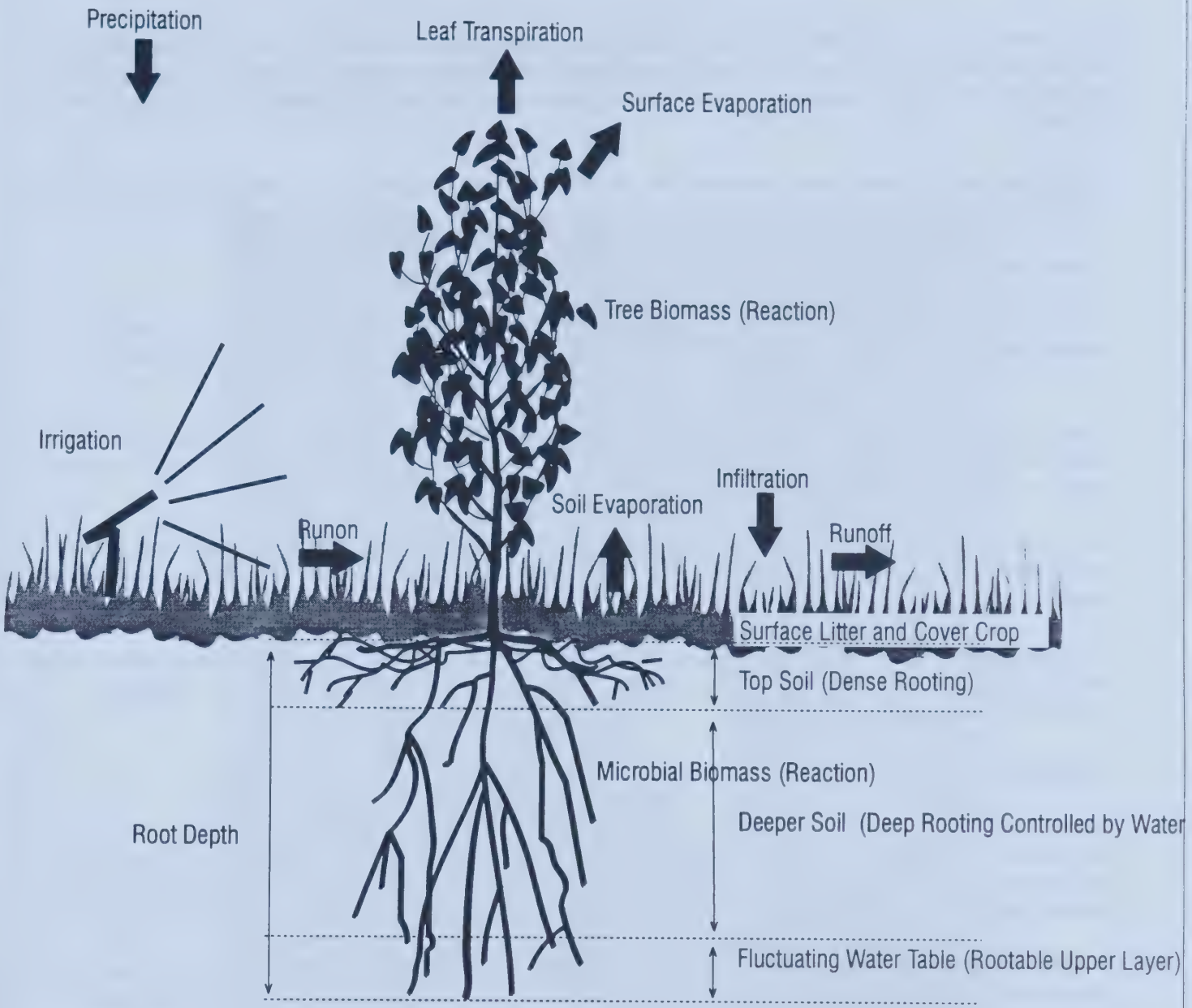
Most landfill sites are in rural or semi-rural areas. Trees planted on the landfill site help it blend more readily with the surrounding landscape. Tall trees screen daily landfill operations, such as bulldozing refuse, from adjacent landowners. They also reduce noise and odour pollution from such activities.

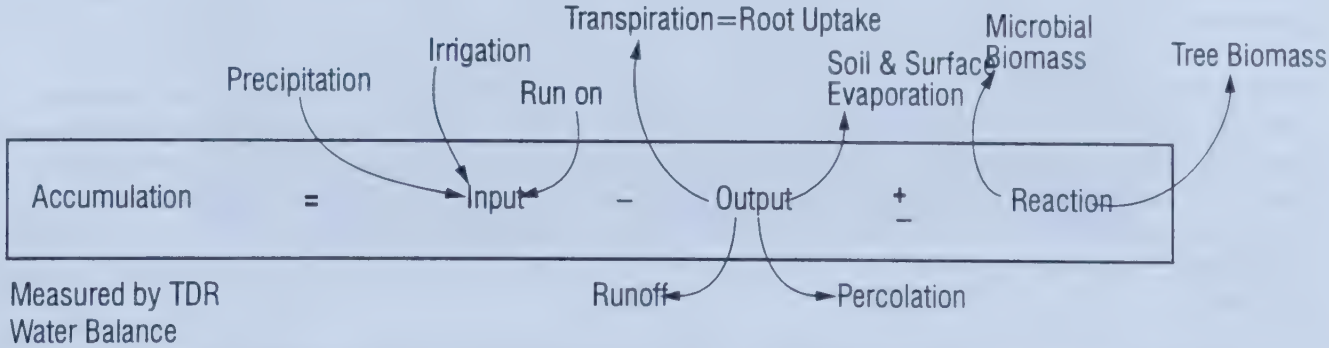
Because of the thick soil layer required for development of an adequate root zone, animals and insects that carry disease or pose a nuisance are physically separated from direct contact with the waste in the landfill. With the poplar tree system, water and air infiltration to the refuse is minimized but not precluded, so it is possible for the waste to continue to decompose and stabilize over the years, rather than being sealed off and preserved, as is the case with synthetic-membrane caps. Furthermore, the poplar tree cap's dense plant root system grows into a cover with the flexibility to withstand differential settling, freeze and thaw cycles, drought, and pressure from landfill gases.

Leachate and Stormwater Management Systems

The basic concepts of the poplar tree buffer are similar to that of the cap, except the system is adjusted to accommodate the treatment of leachate or stormwater runoff. Not only do poplar trees drink it up at an uncouth rate, they can also tolerate a wide range of water quality. In the various applications where they have been employed so far, poplar trees have been able to assimilate nutrients from the leachate or stormwater without impairing their vigorous reach for the sky.

A poplar tree management system usually operates in conjunction with an existing leachate collection and storage system or an existing stormwater system. The goal is to provide a cost-effective natural treatment without adversely affecting the environment. The system design must include the selection of fast-growing poplar varieties with a taste for the "local brew" – varieties that are shown by trials to grow well in the given soils and climate with the least expensive type of irrigation system and to remain healthy as they uptake the special mix of constituents the locale has to offer.





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Figure 1
Principal Water Balance Components

The system is designed for timely irrigation during the summer months to maximize evapotranspiration. An ongoing poplar tree maintenance program is established to maximize tree health. Monitoring is performed to assess and document the changes in the leachate, soil pore water, soil, crop, groundwater, and soil moisture content.

Poplar trees have a greater uptake rate and a longer uptake season than grass, as illustrated in Figure 2. Being densely planted, poplar trees require less land areas than grass.

Where Poplar Trees Will Work

The climatic zone for hybrid poplars corresponds with that of cottonwoods. A wide range of soils can be suitable with appropriate soil amendments and site management. Some leachates with toxic pollutants – herbicides, for example – may require dilution or special site management, such as blending with stormwater.

In arid climates with less than 20 inches of annual rainfall, poplar trees must be irrigated to survive. In wet climates with greater than 60 inches of annual rainfall, irrigation may not be beneficial to the trees, but, in most cases, land application permits can be obtained.

In Hawaii, southern California, and Florida, poplars do not perform well because they require a cold dormant period. Eucalyptus trees are a better choice for these areas. In extreme northern climates, willows may be more suitable.

Obviously, poplar tree systems are not a cure-all for all kinds of landfills everywhere. Each application must be analyzed for feasibility on the basis of site-specific information. The system must be properly designed, constructed, and operated.

Implementation

Implementation of a poplar tree treatment system or cap begins with a site evaluation regarding climate, soils, available cover materials, water balance, the constituents of any leachate and stormwater that will be applied, and the structural and surface characteristics of the landfill. If the project appears to be feasible and desirable, steps are taken to secure regulatory acceptance at the conceptual level and throughout the course of the project.

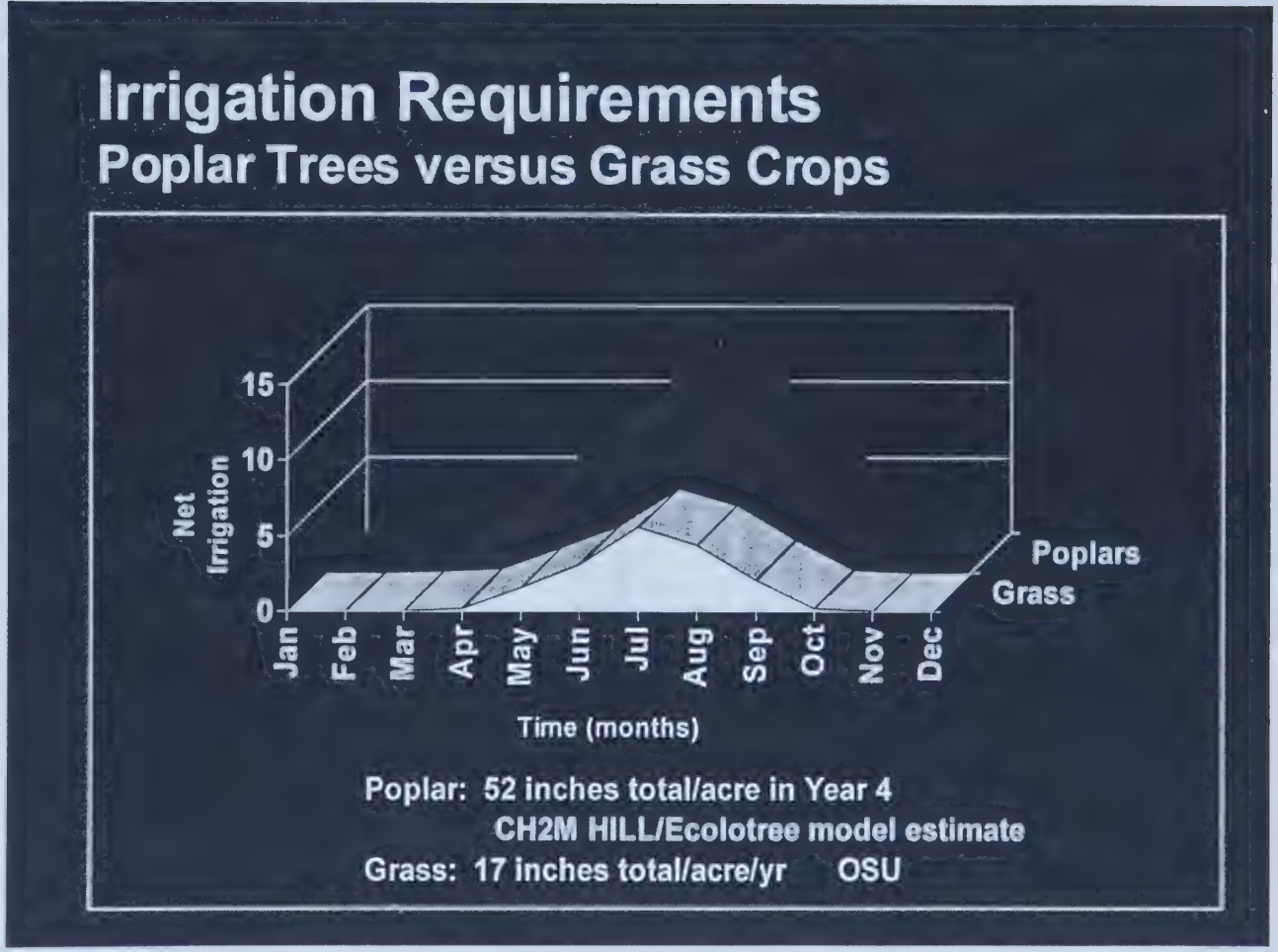
Plans are then prepared for planting of the poplar trees and ground cover plants, amending the soil, tree stress management, and tree harvesting. Any irrigation and control system needed is designed. Based on the site conditions and operational and regulatory requirements, a monitoring plan is devised and the consequent monitoring system is designed. The landfill site closure plan is modified to incorporate the poplar tree system approach.

Implementation entails preparing the site with soils and soil amendments, installing the irrigation system, purchasing and planting the trees and grass, installing the monitoring system, and training onsite staff to operate, maintain, and monitor the system. At the end of the first year, a site assessment is performed and an annual report is prepared regarding soils, tree survival and growth, water balance, irrigation system efficiency, environmental protection, and recommendations for system improvements. Depending on the situation, it may be advisable to proceed in phases – prototype, demonstration, and full-scale – to identify the optimal system for the site.

Cost Savings

In comparison with synthetic membrane cover caps, poplar tree systems offer potential cost savings of 20 to 40 percent for the following reasons:

Figure 2


Irrigation Requirements
Poplar Trees versus Grass Crops
Net Irrigation
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Time (months)
Poplars
Grass
Poplar: 52 inches total/acre in Year 4
CH2M HILL/Ecolotree model estimate
Grass: 17 inches total/acre/yr OSU

- Specially skilled contractors are needed to install membrane caps. The pieces must be welded together over a large area and carefully laid to avoid rips. The soil cover must also be installed with precision to avoid disturbing the membrane. The undertaking is labour intensive. In contrast, the soil base for poplar tree caps can be installed by landfill staff using existing equipment. Specialty care is required, however, to install any irrigation system and to plant the trees.

- A tree cap can incorporate more refuse material, thereby conserving landfill air space. Material such as yard debris, sludges, and petroleum-contaminated soils that are usually landfilled can be applied to the cap of closed areas.

- Because a tree cap absorbs precipitation, rather than deflecting it like a raincoat as a synthetic membrane does, it generates less stormwater runoff. Consequently, the stormwater collection channels, detention pond, and treatment system can all be reduced in scale and their costs can be reduced by 20 to 50 percent. In addition, stormwater runoff can be collected and used to irrigate the poplar tree cap, greatly reducing or eliminating the amount of stormwater that goes offsite.

- Long-term monitoring obligations are less for poplar tree caps because differential settlement is not a concern. With synthetic membranes, differential settlement can destroy the integrity of the seal and require repairs.

- A tree cap can be compatible with the same gas collection system that would be installed for a membrane. Maintenance of the gas system is similar for both types of caps. If a gas collection system is not desired, the tree cap can be designed to breathe and vent gas naturally.

Table 1 compares the costs of conventional systems with poplar tree systems. For leachate management applications, the cost of installing the poplar tree systems is equal to or less than that for conventional crops. Poplars require a smaller land area, which can reduce operating costs. Further reductions in maintenance and site management costs are possible.

	Typical Conventional Systems		Tree Systems	
Landfill Application	**Construction Costs**	**Annual Operations and Maintenance Costs**	**Construction Costs**	**Annual Operations and Maintenance Costs**
Cover Cap	$250,000/ha	$250/ha	$75,000/ha	$300/ha
Leachate Treatment	$1.30/m^3	$2.60/m^3	$2.60/m^3	$1.30/m^3

Table 1
Cost Comparison of Tree Systems with Conventional Engineered Systems (U.S. $)

Compared with pumping or trucking leachate to publicly owned treatment works (POTWs), poplar tree leachate management systems offer cost savings from 30 to 80 percent. Compared with leachate recycle injection systems, the costs are about the same. The poplar tree system, however, provides the added benefit of trees, which can be harvested or used as wildlife habitat, and it reduces leachate concentrations at the site more rapidly than leachate recycle injection systems.

Harvesting can occur every 6 to 10 years and be used to offset some of the costs of the system. Poplar, a "white wood," is one of the leading hardwoods used in the pulp and paper industry. It is also used as fuel and to make

matches, toothpicks, and chipboard. If harvesting is desired, the wood products industry is typically considered in the design of the site to help ensure a consistent product and ease in harvesting.

Conclusions

In conclusion, the use of poplar trees at landfills to improve final closure cover caps and to treat and monitor leachate and stormwater runoff offers significant advantages. These systems are perfect for cover caps and landfill sites because they provide long-term landscaping and beautification, with proven economical treatment capability. Further work in the implementation, evaluation, and refinement of these systems would be beneficial.

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PIPELINE RECLAMATION CRITERIA DEVELOPMENT IN ALBERTA

A.W. Fedkenheuer and J. D. Burke

NOVA Gas Transmission Ltd.
Calgary, Alberta

ABSTRACT

Discussions regarding assessment of reclamation success following various land disturbances have been ongoing for a number of years in North America. In Alberta the emphasis was initially focused on coal and oil sands mines. This was followed by discussions on how to assess oil and gas wellsites and pipeline reclamation success. The objective of reclamation is to have equivalent land capability at the time of application for a reclamation certificate on the disturbed land. The traditional approach for wellsites has been to use an individual parameter-by-parameter comparison and pass/fail system. This was also proposed for pipeline reclamation. Some in the industry felt that there were different approaches possible to evaluate equivalent land capability. NOVA Gas Transmission took the lead in putting together a team of people (NGTL Soils Advisory Board) from other companies, various government regulatory groups, consultants, and personnel from Agriculture and Agri-Food Canada, Alberta Agriculture, Food and Rural Development and the University of Alberta. The objective is to develop a relatively easy-to-use, cost-effective reclamation evaluation tool. Various approaches were field tested in fall, 1997. The approaches were revised and will be field tested in additional geographic areas of Alberta in 1998. This paper describes the process and progress to date.

Introduction

Pipelines have been used for transporting a variety of substances, especially water, for many years. More recently they have been used to transport natural gas and oil. Mutrie and Gilmore (1995) estimated that Alberta has over 2,000,000 kms of pipelines in the ground. Most people are not aware of the presence of pipelines because they are generally buried and so are rarely seen as the soil over them continues to support pre-disturbance activities such as agriculture, forestry, urban and rural communities, and wildlife habitat along with other activities. However, as more people have become aware of the environment, there has been an increasing concern about the impact of pipelining.

With this environmental concern about the impacts from construction of pipelines has come legislation governing their construction, operation and decommissioning. Within Alberta there was no legislated requirement for the reclamation of disturbed lands prior to 1963 when the Surface Reclamation Act was proclaimed (Brocke, 1988). Ten years later, in 1973, the Land Surface Conservation and Reclamation Act was proclaimed. This new Act required that environmental protection and reclamation be part of the development planning (Landsburg and Fedkenheuer, 1990). A review and approval system that included Environmental Impact Assessments and Development and Reclamation Approvals was implemented. Subsequent changes were made in 1983 and more significantly in 1993 with the passage of the Alberta "Environmental Protection and Enhancement Act" (Alberta Environmental Protection, 1994).

It is important to note that, in Alberta, there are Class 1 and Class 2 pipelines. Class 1 pipelines require a Conservation and Reclamation Approval, while Class 2 do not require government approval to construct them. The dividing point is an index value of 2690 (pipe diameter in mm x length of the pipeline in kms). Class 1 pipelines are those greater than 2690, while Class 2 pipelines are less than 2690. It is important to note that both classes of pipelines require a reclamation certificate upon abandonment.

Legislation also brought the requirement to return disturbed land to an equivalent land capability at the time of abandonment. Equivalent land capability is currently defined as, "The ability of the land to support various land uses after reclamation is similar to the ability that existed prior to any activity being conducted on the land, but the ability to support individual land uses will not necessarily be equal after reclamation" (Powter, 1998).

If the requirement is to have equivalent land capability at the time of application for a reclamation certificate, there is a need to be able to measure equivalent land capability. Some documentation is required to enable the regulator to acknowledge that the area is suitably reclaimed and to release the proponent from further reclamation liability, as well as to assure the public that a suitable reclamation job has been done. This documentation has been difficult to obtain agreement on and it has been the subject of much discussion since the mid-1980s. The definition of reclamation success and how to measure it was the topic of a workshop in 1992 (Mahnic and Toogood, 1992). Following the workshop, focus shifted to oil and gas wellsite reclamation criteria development for several years where a parameter based checklist was developed and used. For these areas, specific individual parameters are compared on and off the wellsite and each must pass or the site fails.

There has been a desire by some to utilize this system for pipelines as well. Others have suggested using a capability rating system such as has been used in the agricultural area for many years. It is recognized that some modifications may be required to either system if they are to be applied to pipelines. These two approaches reached a stalemate in 1996. It was at this point that NOVA Gas Transmission offered to take the lead in developing a land capability rating system so others could better see what it might contain, how and if it might work better for pipeline reclamation assessment. This paper addresses the approach used and the results of the approach.

Why Have Standards

As discussed previously, once there is a requirement in place to return land to an equivalent land capability at abandonment time, there is a need to be able to assess whether this requirement has been met. In a manner similar to a coal mine, it is useful to know how one's reclamation is going to be assessed at the "end of the day". In this way, during pipeline construction planning and the operation of the pipeline, the operator, the regulator and the public, are always aware of what the end goals are and can plan reclamation activities accordingly to meet the requirements.

We believe it is in the interest of all parties to have standards in place that are both scientifically meaningful and achievable. This gives industry an opportunity to meet or exceed those standards and provides an opportunity to improve construction and operating practices and further minimize any environmental impacts. With the current status of no pipeline reclamation standards in place, the operator does not know what to focus on at the various stages of a pipeline (construction, operation, retirement). Having standards in place helps the regulatory bodies and the general public as they know what is focused on in the pipeline industry. Also important in today's financial world, the reclamation liability at any one point in time can be very difficult to determine. This has very significant cost implications for industry as reclamation liabilities have the potential to significantly limit a company's borrowing power, the overall balance sheet and the environmental report card. These are important items for a company such as NOVA Gas Transmission Ltd., with over 22,000 kms of pipe in the ground.

Implications

It is not clear what the status of pipeline reclamation in Alberta is. It is not known if 50 percent of pipelines should fail reclamation evaluations or whether 5 percent should fail. Based on the number of kms of pipeline in the province and the small number of landowner complaints, some individuals feel the true failure percentage is quite low (15 percent or less). Others suggest it may not be so low. Generally there seems to be agreement that pipelines have fewer reclamation problems than wellsites. However, it is clear that the cost implications of a poorly designed reclamation evaluation system are large.

Employing the wellsite criteria, as some have suggested, has the potential to be a large cost to industry and the public. For example, it has been estimated that the cost of using a wellsite type approach for pipeline reclamation assessment would cost as much as $2,000 per km or $20,000 for a 10 km line. Using these figures, if all the 2,000,000 km of pipelines that Mutrie and Gilmore (1995) estimated were in the ground in Alberta were to be assessed, the cost would be about $4 billion in current dollars. This is just the cost to find out whether, according to wellsite-like reclamation criteria, a pipeline is suitably reclaimed. Some feel that there are more cost-effective approaches which can do a very good job of evaluating whether equivalent land capability has been met.

In addition to the direct assessment dollar costs there are other implications. The NGTL External Soils Advisory Board identified some of the important components of a pipeline reclamation evaluation tool as: being easy to use; having scientific validity; providing reproducible results; being cost-effective; measuring the important environmental parameters; and, defining how to measure those environmental parameters. If a system can not achieve these items, there is a risk that significant parameters will not measured and may need to be measured at a later date (increased cost) or there are potential environmental liabilities which may not be addressed (increased risk). If the results are not reproducible there will likely be costs associated with litigation as different investigators working for various involved parties arrive at different results. Scientific validity is a requirement for the system as without it there will likely be litigation as various parties dispute the methodology and end results. There are many environmental parameters which can be assessed, some of them very costly, and so it is important to key only on those of significance for addressing whether equivalent land capability has been met. Otherwise valuable time and people resources are being wasted.

The point is, reclamation evaluation standards must be well thought out so that what needs to be assessed, is, and that solving one issue doesn't create unwarranted new issues. It is imperative that government, industry and the public approach the development of reclamation standards from the perspective of what really needs to be assessed in order to ensure we have equivalent land capability at pipeline abandonment time.

Standards Alternatives

There are currently two reclamation evaluation systems presently in use in Alberta, one for oil and gas wellsites (wellsite criteria) and another on mines (a modified agricultural land capability system). Both systems use many of the same landscape, soils and vegetation parameters, however use of the individual parameters is different.

Generally for wellsites, the single most limiting parameter is used to determine whether a site passes and receives a reclamation certificate or whether it fails and must undergo either active or passive remediation before it can be again considered for reclamation certification. Examples of single parameters that can fail a site include: topsoil depth, topsoil colour, admixing of surface and subsurface soils, pH, electrical conductivity, organic matter content, weeds, crop vigour and soil texture. The wellsite criteria system does not take into

account any parameters which might have been improved as a result of pipeline construction, for example, elimination of a hardpan, improved pH, or improved texture which can offset degradation of the capability of the land. Instead, the entire wellsite can be downgraded based on one parameter taken in isolation.

In the mining industry a system is used which combines landscape, soils and vegetation parameters to come up with a capability rating. In this case, reclamation assessments take critical soil, landscape and vegetation parameters and rates them for improved or reduced levels and these parameters are used to develop an overall reclamation rating of the site. In this approach, some trade-offs are possible as some parameters may be made better as a result of pipelining and these are taken into account when evaluating whether a site has attained equivalent land capability at the time of pipeline abandonment. It is felt, by some, that this is more the way vegetation views the pipeline disturbance at the time of application for a reclamation certificate.. That is, equivalent land capability doesn't necessarily mean that all parameters must be the same as they were prior to pipeline disturbance, but it does mean that the end result must be equivalent land capability. Under the capability systems developed and used in the agricultural sector for many years, class boundaries are 15 to 20 points apart depending upon whether they are on the higher or lower numbers. For use in pipeline reclamation success evaluation it is proposed that if a site on the pipeline right-of-way is within 15 to 20 points of the off right-of-way similar area control, the site has been returned to equivalent land capability.

The Process

Pipeline reclamation standards were discussed since the mid-1980s in Alberta with an ebb and flow in the intensity of discussions, all of which led to a pipeline reclamation success measurement workshop in 1992 (Mahnic and Toogood, 1992). Following this meeting emphasis shifted to developing reclamation criteria for assessing reclamation on oil and gas wellsites. There were a large number of wellsites classified as abandoned, with many of them classified as "orphaned" (no traceable owner) and there was a desire to get wellsites certified more quickly in the future, while the ownership was still clear. As the rate at which new wells were being drilled each year increased, there was concern that the abandoned wellsites needed to go through the certification process so they could be "taken off the books" of both industry and government. Of major concern also, was the manpower requirement to complete all of the certifications.

In 1995 interest in reclamation standards for pipelines again began to increase. Several joint government-industry working groups were established. In mid-1996, a version of the wellsite reclamation criteria was modified and tabled for consideration as pipeline reclamation criteria. As discussed earlier, the wellsite criteria are basically a parameter-by-parameter pass or fail system.

To deal with the issue of developing a capability-based assessment of pipeline reclamation, a varied group of people were required around the table. A group of people consisting of representatives from government regulatory bodies, industry and also some independent experts, was invited to participate. The group was formally named the NGTL (NOVA Gas Transmission Ltd.) External Soils Advisory Board and consisted initially of: Adolf Bruneski, Forest Management Division, Alberta Environmental Protection; Jim Burke, NOVA Gas Transmission Ltd.; Dr. Al Fedkenheuer, NOVA Gas Transmission Ltd. (Chairperson); Heather Gerling, Public Land Management Branch, Alberta Agriculture, Food & Rural Development; Tom Goddard, Conservation and Development Branch, Alberta Agriculture, Food & Rural Development; Vasile Klaassen, PanCanadian Petroleum Limited; Len Knapik, Pedocan Land Evaluation Ltd.; Leonard Leskiw, Can-Ag Enterprises Ltd.; Dr. Anne Naeth, University of Alberta; Dr. Wayne Pettapiece, formerly with the Research Branch, Agriculture and Agri-Food Canada; Chris Powter, Land Reclamation Division, Alberta Environmental Protection; and Rob Staniland, Talisman Energy Inc. Dr. Naeth and Len Knapik withdrew from the committee due to time availability constraints.

A key component of this board is the members not directly involved in industry, government or consulting, particularly, such people as Tom Goddard and Dr. Pettapiece. They have brought both a practical and scientific perspective to the Board, as well as considerable experience. For example, Dr. Pettapiece has worked for many years in the area of assessing land capability.

A key activity in the early meetings of this board was to provide everyone with a minimum level of understanding of the problems in pipelining, and to have members put forth their issues and create discussion around each issue. These issues were either included for further discussion or "parked" for bringing to the attention of others. During this process discussion became more open and a framework for working the reclamation standards issue was developed.

The Board agreed that it's primary short-term objective was to work to develop a pipeline reclamation evaluation tool. There was much discussion as to when this tool would be applied, either at post-construction or upon abandonment of the pipeline or at both times. It was agreed that the Board would focus on abandonment standards, those which would be applied at the end of the life of a pipeline. In this way, the operator would know, in the planning stages of construction, what would be measured at the end. This would encourage good planning of soils handling and other environmental issues during construction in order to minimize the cost over the life of the pipeline.

Important components of the reclamation evaluation tool are seen by the Board to be: that it is scientifically valid, relatively easy to use, cost-effective, provides reproducible results, measures important environmental parameters and defines how to measure those environmental parameters. It was also a desire that time not be spent initially building new systems but to evaluate systems and processes already available. The Board has met a number of times over the past months to set goals, objectives and timelines and to develop the approach to use. In the end, it was decided that a visual assessment as well as a couple of others, one with a more detailed level than the visual, but not requiring laboratory analyses, and another requiring laboratory analyses needed to be developed. As well, the Land Suitability Rating System (Agronomic Interpretations Working Group, 1995) and a version of the wellsite reclamation criteria system (Wellsite Criteria Working Group, 1995) were used. Along with these systems, a landowner reclamation evaluation form was also developed; this is currently being tested with landowners who were in the 1997 and 1998 field tests.

Following agreement on the systems to use, the Board retained three senior consultants to take the systems to the field and evaluate their field performance. This was done in October and November, 1997. The consultants were sent to three areas of the province and asked to employ the systems on five pipeline segments, chosen by representatives of the Board, in each area. The consultants were not to be on the same site at the same time, nor were they to discuss their findings with each other until after their reports had been submitted to the Board. One day was spent in the field by the Board and each consultant was visited at a different pipeline location. Subsequent to the receipt of the reports, three members of the Board undertook to summarize the consultants reports into one summary report.

The Board then took the results of the 1997 field evaluation and the consultants recommendations and revised the evaluation tool for a re-test in the field season of 1998. A three step process has resulted. One step is the landowner reclamation evaluation form which reflects the parameters being assessed by consultants. The other steps are being done by consultants and involve two levels, the first being a more quantified version of the visual system and the second a modified version of the Land Suitability Rating System. The intent is to again do a summary report and revise and hopefully finalize the systems during the winter of 1998-99.

The larger percentage of the direct funding of the consultants and other activities has come from NGTL, with significant funding also coming from the Canadian Association of Petroleum Producers. The latter is a group of oil and gas producers.

Results

Accomplishments of the Board to date consist of: development of Board objectives, an evaluation tool framework, tool parameters, and an evaluation process; completion of a field evaluation study in 1997, initiation of the 1998 field study using three external consultants in each year; comparison of seven systems initially in 1997 and comparison of selected modified systems in 1998, and the development of a summary report of the 1997 field study.

Specific 1997 results from the field study are:

- agreement on pass/fail results among the three consultants who visited the same sites was less than 45 percent in all of the reclamation evaluation systems tested in 1997, except for the Visual system where there was about 90 percent agreement,

- across the 18 quarter section in the study, the average topsoil depth was 16 cm (+/- 8 cm) both on and off the pipeline right-of-way. Topsoil depth recordings by the consultants reflected this natural variability as one consultant reported finding 10 to 26 cm of topsoil, another reported finding 10 to 19 cm and the third consultant reported 12 to 26 cm. These readings were all for the same quarter and were done by well-qualified soils professionals. Again, this was the natural variability on an agricultural field,

- topsoil thickness alone is a poor indicator of reclamation success as systems that relied heavily on topsoil depth as a measure of reclamation success had failure rates of greater than 40 percent based on topsoil depth by itself. For example, the Wellsite Criteria Access Roads system had a failure rate of over 40 percent due to topsoil depth alone.
- This should not be surprising when the natural variability, discussed in the previous point, is taken into consideration,

- removing the topsoil depth parameter resulted in failure rates of about 15 percent,

- the visual parameters caught about 73 percent out of 183 right-of-way transect failures. This means many of the failures were apparent to the evaluator before subsurface parameters were evaluated,

- two out of the three consultants recommended the Visual System and the Land Suitability Rating System (LSRS) be retained and modified for further field testing in 1998. This was done, and is what the consultants are using in the 1998 field study.

A Landowner Reclamation Form has also been developed, employing similar parameters as the Level 1 part of the system. This form is being given to the landowners on whose property the 1997 and 1998 field study was conducted. When returned, the landowner responses will be compared to the consultant findings. The reasons for this are twofold. One is to see if the parameters important to the landowners have been included in the Level 1 and the second is to evaluate the possibility of using the landowner as the first step in evaluating reclamation on the property. The concept is that the landowner (or the occupant) is working the land and should have a good long-term understanding of the state of the pipeline reclamation. This would conceivably give the landowner an integral role in the reclamation certification process. The role of the landowner in the

reclamation certification process has not been fully investigated to date, however, their input and expertise is an important resource that the NGTL External Soils Advisory Board is attempting to tap with this step.

Conclusions

In conclusion, the following are some key items that have been important in getting the NGTL External Soils Advisory Board to the point where it is today:

- Team building. This project has been underway for two years with part of this time spent being necessary for the group to learn to effectively work together and build trust. Often the problem which needed to be dealt with and overcome was philosophical in nature and not technical. A number of ideas have been brought to the discussions and carried forward to be tested in the field.

- A key to the group's success has been taking the time to separate out issues. For example, taking time to separate construction issues from evaluation of equivalent land capability issues upon abandonment, and then deal with them individually and not try to answer all the questions at one time, in one meeting.

- Another key to the group's success has been the presence of independent participants around the table. This is in addition to government and industry stakeholders. These independents have brought a third party point of view to the discussions without the bias (real and/or imaged) of the other government and industry members.

- Landowners are an important source of input and expertise and ways are being investigated to obtain and make use of their input.

- Also important is the presence of a chair, or facilitator, to keep the group focused and moving along, while checking to keep everyone participating and comfortable with the proceedings.

- Field testing. Work is continuing on developing a proposed system, using small scale field testing, before implementing the system on a large scale across the province.

There have been many difficult issues, with many still to be resolved. The Board is, however, working to simplify the systems to be used and yet keep them meaningful and valid. How to best answer the question of when is a pipeline successfully reclaimed and when does a pipeline truly require additional remedial work, is still being discussed. However, with the interest and participation experienced to date, we are confident that government and industry, working together with the public, can solve the issues around pipelines and associated facilities reclamation certification.

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THE DON VALLEY BRICK WORKS: TRANSFORMATION TO A CITY OF TORONTO PARK

Teresa Bosco

Toronto Parks and Recreation, Metro Division

ABSTRACT

The Don Valley Brick Works (DVBW) is a former industrial complex and quarry located in a major river valley system that flows through the centre of Toronto. The DVBW manufactured bricks for a century, ending in the late 1980s. The quarry excavation revealed fossils and rare geological formations. Although, the quarry is now partially filled in, it is still an internationally significant geological site and a provincially significant Earth Science Area of Natural and Scientific Interest. The site has recently been transformed into a city park that reflects a part of Toronto's industrial past, its geological and fossil record, and natural heritage. Its rehabilitation takes place within the context of grassroots-initiated visions to restore the entire valley and to "bring back the Don."

The rehabilitation of the site has many facets that make it fitting of the conference themes: the location in the heart of Toronto, community interest, contribution of the DVBW's products to Toronto's development, geological and paleontological significance, and the management of a physical and social legacy to improve the ecological health of the valley.

Introduction

The Don Valley Brick Works (DVBW) is a former brick making operation lying within the Don River valley and floodplain in the City of Toronto. Under public ownership and management, it is in the process of being naturalized and converted into a city park and interpretive centre. The DVBW's industrial, ecological and internationally significant geological history form a unique opportunity for the protection and communication of natural and cultural heritage in the city. Transforming the site from a former quarry and manufacturing plant also presents a number of issues and approaches that face both the fields of restoration and reclamation.

Ecological restoration, as a process for dealing with disturbed areas, places an explicit emphasis on achieving ecological integrity. Reclamation, however, particularly with respect to pits and quarries, is conventionally defined as a way of re-using or altering an area to make it useful for human purposes, e.g., once extraction activities are completed. Thus, the two approaches are contrasted in that one is ecocentric and the other is anthropocentric. However, these practices are often combined in application when the aim is to serve both humans and wildlife. In an urban setting this is more common as it is being realized that this combination is necessary for continued existence of sustainable natural areas within a city. Both reclamation and restoration were carried out in the Don Valley Brick Works.

The DVBW Site and Surroundings

The Don Valley Brick Works is a 16.5 hectare site (TRCA, 1993) located in the new City of Toronto and the southwestern portion of the former Borough of East York (Metropolitan Toronto, which included six local municipalities -- the cities of Toronto, North York, Etobicoke, Scarborough, York, and the Borough of East York -- and one regional government, the Municipality of Metropolitan Toronto, amalgamated on January 1, 1998. Toronto now has a population of 2.4 million and an area of 630 km^2.). The DVBW faces Bayview Avenue (an arterial road) to the south. It is bordered to the west by Chorley Park (a local park), the Moore Park

Ravine, and the upscale residential neighbourhoods of Moore Park and Rosedale beyond the parks. Bayview Avenue curves northward to the east of the CPR rail line bordering the park to the east. The Don River is just east of Bayview Avenue. Figure 1. shows the DVBW in its site context.

The site is located near what was a busy commercial area of Toronto around the turn of the century. The Belt Line Trail which runs through Moore Park Ravine was a commuter rail line that served the rapidly expanding suburbs north and west of the City of Toronto. The CPR rail line off Bayview Avenue once had a busy freight and passenger rail stop just south of the DVBW (Freeman, pers. comm.).

The DVBW is also located in the Don River floodplain. The Don River roughly runs through the geographic centre of Toronto and is perhaps, one of the best known river and valley systems in the city. Several parks with naturalistic themes are located throughout the valley. The Don River and its valley have been channelized, eroded, loaded with salt, sediments, and heavy metals from the adjacent expressway, and used as a sewer and garbage dump by abutting industry and other land uses in the time that Toronto has been settled. Recent efforts to restore health of the Don Valley and the entire watershed began in the early 1980s and still continue.

The site has been divided into six parts for the purposes of this paper, based on its topography and the plans for its restoration and reclamation. These are: Building Area, Quarry Area, East Ridge, West Wall, Mud Creek Channel, and North Slope. A site plan is illustrated in Figure 2.

Eleven buildings that were constructed at various times over the century of brick making still stand at the front or south end of the site facing Bayview Avenue. Bayview provides the only motor vehicle access to the DVBW. Some remnant machinery from the brick making operation still remains in the buildings.

The West Wall is a slope of natural vegetation that abuts Chorley Park and the Moore Park Ravine. This provides easy public access by pedestrians and cyclists and is currently the only area with direct linkage to another park. The West Wall is geologically significant as it is partially comprised of shale bedrock (the Georgian Bay Formation) with several types of fossils embedded in it (e.g. trilobites and cephalopods) (Metro Parks and Culture, Undated).

The Quarry Area is a relatively flat area of 10 ha that includes the entire DVBW site except for the slopes, and the Building Area. This was the area that was excavated during brick making and has since been partially filled in. The fill that has been placed there ranges from approximately 3 ft. deep closest to the buildings, to 140 ft. near the North Slope (Freeman, pers. comm.). This is where many of the modifications for parkland creation have occurred.

Mud Creek once flowed from Downsview to the Don River. It is one of many rivers that were lost or buried during the Toronto's development. Part of the buried creek follows the Moore Park Ravine follows before it enters the DVBW in the northwest portion of the park.

The North Slope is the site's most striking natural feature – at the northernmost end of the DVBW, an 80-foot cliff rises to the upper tableland. It has been designated by the province as a Provincially Significant Area of Natural and Scientific Interest. This North Slope is an internationally significant geological site as it has rare, exposed deposits and fossils from the most recent two Ice Ages and the Interglacial period between them that occurred during the Pleistocene (2,000,000 to 10,000 years ago) (Eyles and Williams, 1984). This unique sedimentation structure has been documented extensively, beginning with Arthur Coleman, a renowned geologist who in 1894, "identified exposed fossil remains as interglacial and correlated them with earlier sporadic finds along the Don River." (Eyles and Williams, 1984).



Figure 1. The Don Valley Brick Works (DVBW) Site Context (Including Potential Linkage Sites, Don River and Other Nearby Parks, and Major Toronto Streets)

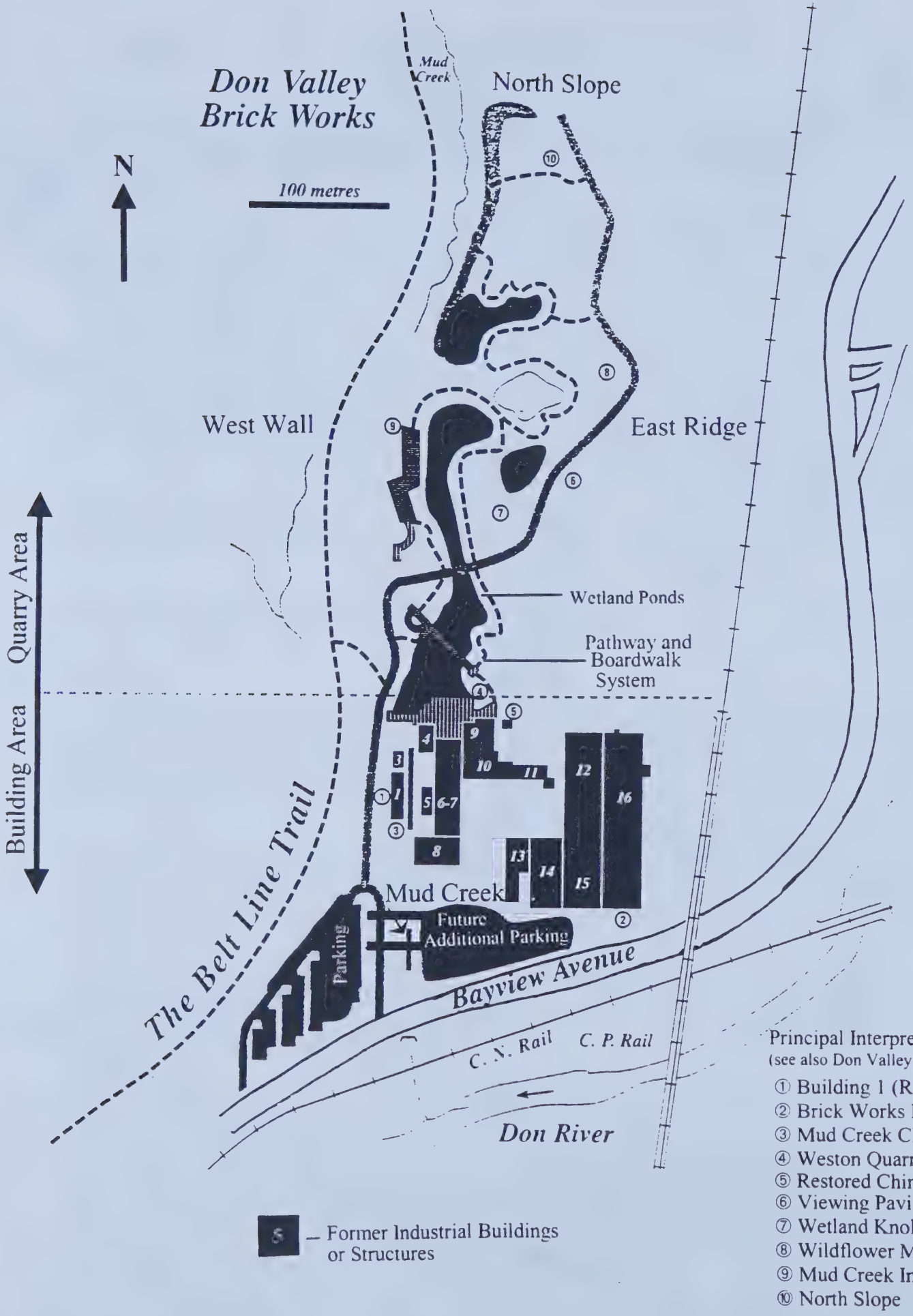


Figure 2. Don Valley Brick Works Site – Some Existing and Planned Features from Revised Master Plan

The Brick Making History

It is said that in 1882, the Taylor brothers accidentally discovered the potential for excavation of clay to make bricks while digging post holes to build a fence (Metro Parks and Culture, Undated). In 1889, the Taylors founded the Don Valley Pressed Brick Company on the site (Unterman et al. 1994). Since that time, the DVBW site has contributed greatly to Toronto's built heritage – many of the city's landmarks were made from the bricks produced there such as Massey Hall, the Canadian National Exhibition's Pure Food Building, and University of Toronto's Hart House, Convocation Hall, and Trinity College (Freeman, pers. comm.).

The functioning brick operation also did much to improve the state of the brick making industry in Ontario. Unterman et al. (1994) state that with the "unique combination of clays and shales on the site the DVBW could produce a full complement of brick and block products in a wide range of colours." The operation was highly regarded, known to be at the forefront of many new processes (e.g., stiff mud), technologies (e.g., muffle kilns) and products (e.g., shale and enamel bricks). Moreover, to have survived as a functioning company for so long, it had to adapt to changing trends in desirable brick types, the booms and busts of the construction industry, and various other changes that affected it during such a dynamic century (Unterman et al. 1994).

The DVBW had different names during its operation due to some of the changing ownership, all of which occurred in the years 1901, 1909, 1920, 1929, 1921, 1956, and 1965 (Otto, 1998). In 1984, the site and facilities changed ownership again, the results of which would prove to be quite consequential.

Public Acquisition

Although it experienced many different economic conditions, the site was always used as a brick making facility. In 1984, however, the new owners had no interest in brick making. A different company (Brampton Brick) bought the machinery and equipment from the new owners, leased the physical plant, and continued to operate a brick industry there until 1989; a century after brick making had begun on the site, rendering the DVBW the longest operating brick company in Ontario (Unterman et al. 1994).

Since the formation of the Metropolitan Toronto and Region Conservation Authority (now the Toronto and Region Conservation Authority or TRCA) and the Metro Toronto regional government in the early 1950s, there has been a strong connection among land acquisition, flood plain management, parkland management, and conservation. The DVBW was a prime site for public acquisition in 1984 and had long been identified as such by the TRCA. The DVBW was also considered suitable for regional parklands, given its size, location and potential for connection with other parkland and greenspace managed by the municipal government in the Don River valley. Moreover, the DVBW's geological and paleontological significance would fit in well with the vision of regeneration along the Don River and indeed throughout all Metro's regional park system.

When the DVBW site went up for sale in 1984, the need to restore the Don River, particularly the lower reaches near the city core, to a healthier condition was gaining support in public, academic, and government circles. Public ownership of the DVBW as greenspace was considered by many to be an important contribution to the health of the river and the valley. In addition to this growing sentiment, there was also an historic interest by the TRCA to acquire the DVBW as part of a regional program of flood plain and hazard land management.

Despite these compelling reasons for public acquisition, the DVBW's sale price of $4,000,000 was considered too high by the provincial government. Consequently, the Conservation Authority was unable to purchase the property based on the usual 50/50 funding formula between the provincial and municipal government. Instead, Torvalley Developments, a land development company, bought the site with the intention of re-selling the land for large-scale residential and commercial development (Unterman et al. 1994).

Torvalley immediately began plans for development by seeking approval to re-zone the land to residential from conservation, and by filling the quarry in preparation for construction. As these activities continued, public concern increased.

The role of the public in stopping Torvalley was pivotal. As soon as the developers initiated the re-zoning process, local ratepayer groups began to oppose it. Indeed, a new group, the "Friends of the Valley", was created to focus specifically on the task of preventing Torvalley from developing the site (Friends of the Valley, 1987).

When the province realized that something had to be done, bids were made to buy the site from Torvalley but they would not sell. East York council heeded the appeal of Friends of the Valley and successfully requested the Minister of Culture and Tourism to issue a Stop Order on filling to Torvalley (Ministry of Culture and Tourism, 1985). The TRCA eventually expropriated the land from Torvalley. By then, however, the price was considerably higher with the final acquisition cost over $21,000,000.

In 1987, the TRCA finally owned the DVBW and in 1989, Metro Parks accepted the site for parkland development and management. Following these events, a plan for the site as a park was now necessary.

Park Creation

When the DVBW was acquired by the TRCA in 1987, it was only being used for some brick storage and shipment by Brampton Brick. The buildings were deteriorated and the Quarry Area was partially buried with fill from excavations for new buildings in Toronto's downtown core. The North Slope, once spectacularly exposed at 120 feet high (Mirza Engineering Inc., 1984), was now significantly reduced in height. What to do with the newly acquired site was debated in the media and in the public offices. For example, a botanical garden was proposed to further enhance Toronto's reputation as a world-class city.

A plan was commissioned by the former Metro Parks Department for the DVBW. The Don Valley Brickworks Master Plan (hereafter referred to as the Master Plan), led by Hough Stansbury Woodland Limited was completed in 1990. The Master Plan assessed the site and proposed the revegetation, public uses and facilities, and interpretive programs. It also identified issues that would have to be addressed in the land use conversion process and the preliminary research that would be required. It proposed that the final product should encompass an holistic assemblage of three unique concepts to its visitors: 1. physical connections to the entire Don Valley, 2. fossiliferous North Slope deposits, and 3. role in the community restoration of the Don (Hough et al., 1990).

As a result, some of the proposed attractions, facilities, and themes for the DVBW included: An East Ridge "Don Centre" with lecture halls, offices, viewing pavilions, and interpretive exhibits, a stormwater purification demonstration at Mud Creek, interpretation of the North Slope, a greenhouse complex, a walkway across Bayview Avenue to Todmorden Mills (another regional park and culturally significant site), a parking lot under shed buildings converted into huge pergolas, meadow and natural gardens, marshland and wildlife habitat, and building restoration and mothballing for demonstration, programming, rental space, and food concession purposes (Hough et al., 1990).

The Master Plan was proposed to be implemented in three main phases over fifteen years with a total projected budget of $18,600,000. A budget of $27, 300,000 was delineated if options such as the Don Centre, Greenhouse complex and pedestrian bridge to Todmorden Mills were included (Hough et al., 1990).

Metro Council received the Master Plan favourably, but considered the implementation costs too high to go alone. Council requested, therefore, that the TRCA undertake plan implementation, the intention being that the provincial government would match funds for the work as a project of the TRCA. To some degree, that strategy

to share costs with the province worked, however a much reduced version of the original Master Plan was established as a basis for the TRCA's project. This new plan, referred to here as the Revised Plan, was estimated to cost $5,000,000 (TRCA, 1993).

Implementation of the Revised Plan was initiated in 1997, based on detailed site planning and design led by the Landplan Collaborative and Oleson and Worland. It retains many of the Master Plan's basic themes including ecological regeneration, North Slope protection, public access, and opportunities for attractions and interpretation and includes proposals (added in 1993) to "restore key features of the industrial heritage components." The Revised Plan also proposes that the Quarry Area contain: a butterfly and hummingbird garden, a lowland Carolinian woodlands, a wildlife habitat garden, a bird habitat demonstration garden, a wet scree garden, and a fossil garden (TRCA, 1993).

An Open Wetland Area was also included in addition to other features proposed in the Revised Plan. Over three hectares of Open Wetland Area were created in the Quarry Area with boardwalks weaving throughout and around it. Approximately half of the water area has been designed for future fish spawning. Wetland plants such as pickerelweed (*Pontederia cordata*) are planted closer to the water's edge or directly in the water. The higher portions of the Open Wetland Areas are planted with ferns, shrubs, and wildflowers in order to vegetate the drier portions of this area. Volunteers were and are being used for carrying out most of the Open Wetland Area plantings. These were carried out in the Spring and Fall of 1997 and the Spring of 1998 and are ongoing.

One problem has been trampling of wetland plants by dogs that are being walked through the park. Because the park is new and not yet well publicized, use is considered to be relatively low. Temporary fencing was installed in the Spring of 1998 to prevent future trampling and allow the damaged areas to regenerate.

Pathways connected to the Open Wetland Area boardwalks wind among the planted trees and other vegetation towards the North Slope. It is hoped that shrubbery closest to the North Slope will become a "barrier thicket" (TRCA, 1993) to prevent access and to protect the slope from vandalism and other unauthorized uses.

Toronto is located at the northeastern limit of "Carolinian Canada" (or "eastern deciduous forest") an area restricted to a small portion of southern and southwestern Ontario. A western portion of the Quarry Area has been planted with trees to establish a forest community representative of a Carolinian Canada lowland. Plants include characteristic trees such as the tulip tree (*Liriodendron tulipifera)* and sassafras (*Sassafras albidum*).

Part of the East Ridge was hydro-seeded in 1997 to create a wildflower meadow. Seventy percent of the species in the seed mix are native to southern Ontario and include wild bergamot (*Monarda fistulosa*), Cup Plant *(Silphium perfoliatum*), and several aster (*Aster* spp.) and goldenrod (*Solidago* spp.) species. Monitoring of the success of the plants is being carried out and re-seeding took place in Spring, 1998. Other plans for the East Ridge included plantings "designed to further natural succession, managed succession and protection of habitat" (TRCA, 1993).

Six of the eleven buildings have been fully or partially restored. Building #1 has been fully refurbished to include meeting rooms, some office space, and other facilities amenable to holding events there. Original features have been retained such as some brick wall and wood ceilings. Public washrooms have been installed for park and facility users. As well, some of the windows have been filled with unused bricks that were left on the site. Another building, although inaccessible, has been fitted with metal screening so that remnants of kilns can be viewed from the outside. It has not yet been decided whether the five remaining untouched buildings will be restored, torn down, or mothballed in perpetuity. It is hoped that the buildings may eventually be used for artisan facilities, attractions, trade-shows, and events.

During the DVBW's operation, four large chimneys expelled exhaust from the brick firing process. With one word on each chimney, the chimneys collectively spelled "Don Valley Brick Works" in white bricks and

became an identifiable landmark along the Don Valley and beyond (Metro Parks and Culture, Undated). The Revised Plan called for the restoration of the one remaining chimney for attraction purposes. The restored chimney spells "Valley" and can be seen when driving along the Don Valley Parkway and Bayview Avenue.

It was known from early file plans (Freeman, pers. comm.) and from researching the site for park development in 1994 that portions of Mud Creek had been channelized and redirected through the DVBW so that the water could be used for brick making. The channel was exposed in 1995. The stone wall that had been built to channelize thc creek was virtually intact. Currently, the creek is channeled into a culvert after leaving the DVBW, passes under Bayview Avenue and is piped into the Don River (City of Toronto and TRCA, 1998).

The grade of the culvert is too steep for natural fish movement upstream to the Brick Works but an amendment plan is already underway. As of May 1998, Terms of Reference are in place, the purpose of which are "to develop detailed design plans for the reconnection of Mud Creek from the open channel within the Don Valley Brick Works to the Don River enabling the passage of fish species into the channel and ultimately into the lower ponds for spawning" (City of Toronto and TRCA, 1998).

Two significant efforts have been made to increase the awareness of the DVBW to the public. First, an interpretive brochure was produced as a self-guided tour of the site. Stations at the DVBW correspond numerically to descriptions in the brochure. The brochure is currently in distribution and signed stations throughout the site have already been established. Second, an 88 m long by 4.9 m high mural was erected in 1996 along the south faces of the untouched buildings to illustrate the story of the discovery of the DVBW's geological, ecological and paleontological significance as well as the story of brick making and to celebrate the regeneration of the site (Metro Parks and Culture, Undated).

The total cost of the park creation to this point is approximately $6,000,000. Funding of approximately $4,500,000 was contributed equally by the former Metro Parks and Culture Department and the Province of Ontario. $600,000 was contributed by the Conservation Foundation of Greater Toronto, based on private donations. An additional private donation of $850,000 was made by the Garfield Weston Foundation. This money is responsible for the development of much of the Quarry Area to date (Kershaw, pers. comm.). This portion of the park has now been named the Weston Quarry Garden to acknowledge this significant contribution.

In May, 1998 approval was granted by the City of Toronto for an additional $300,000 to continue development of the DVBW. $120,000 of this money will be put towards additional landscaping. The rest will be used for the completion of various planned on the site (Kershaw, pers. comm.).

Conclusions and Observations

The transformation of the DVBW from a brick producing quarry and factory to a public park that reflects the merging of and relationship between natural and cultural heritage has been formidable. The original ambitious Master Plan has not been realized, due mainly to funding. The more basic Revised Plan, which addressed a more limited area of the site on reduced terms, remains to be completed. More funding is needed to continue and monitor planting, restore the mothballed buildings, ecologically reconnect Mud Creek to the Don River, re-expose the North Slope, and implement an interpretive program.

Possibly one of the most significant challenges facing the DVBW is the need to find the resources and sustainable uses necessary for the conservation of the site's built heritage. The site's buildings and remnant machinery are a testament to the productive capacity of the site and the capital outlay over decades of brick making. The buildings have been left there in anticipation of their use for interpretation of the brick making industry and its effects on Toronto. This is a unique theme for a park in Toronto and it ought to be pursued fully, however, resources to do so remain an issue. What remains to be seen is the level of support that

government, community organizations and private sector partners can muster to preserve this component of Toronto's industrial heritage.

Nonetheless, a plan has been envisioned emphasizing the site's unique combination of industrial history, geological significance, and natural heritage. The plan is in the process of being gradually implemented and is quite fitting with the site with respect to its location within Toronto. The DVBW has been designed to be useable to a potentially large public and to symbolize achievements of sound environmental management applied in an urbanized setting. Moreover, it helps convey to the public that nature and a metropolitan populace can co-exist in a sustainable manner on the same landscape.

At this time, plant communities (wetlands, woodlands, and meadows) are being established. Although still too early to determine success in a scientific testing process, frogs and dragonflies inhabit the wetland ponds, while meadowlarks and other songbirds can be identified. Although the park has not been heavily publicized, people are cycling in it on their way to the Don River, walking their dogs, strolling along the boardwalks, sketching the landscape, and spotting wildlife.

At first, the combination of industry, geology and ecology themes may seem quite incompatible to the uninformed DVBW visitor. However, if it can be communicated that it is only because of the excavation for brick making over a long period of time that the geological significance was discovered – and that this geological circumstances have led to the provision of appropriate climatic, topographical, and pedological conditions for the colonization and adaptation of the current assemblage of native flora and fauna, then the interpretation of the park's natural qualities has been successful.

Private funding for the site has been generous, and is a result of wealth derived from prosperous urban-centred industry and commerce. The significant public funding allotted to the acquisition and development of the DVBW as parkland is only possible with the tax base that a densely populated urban centre can provide. In the case of the DVBW, a large scale effort was needed with more than average park expenditures. Although a motivated public, one that is protective of Toronto's natural features and livability and values its open spaces and natural areas, can be credited with creating the impetus for action, the parkland purchase and creation could not have been possible without sustained government intervention.

The linkage opportunities that the park's location provides for the Don River Valley, and concomitantly for the green space system for the entire city, are exceptional. It is already connected to Chorley Park and the Moore Park Ravine to the west. Via the Moore Park Ravine, a linkage exists to Mount Pleasant Cemetery further north. If the walkway is built to Todmorden Mills, then the DVBW can serve as a gateway to the entire Don Valley park system and subsequently, the Lake Ontario waterfront park system and other river valleys. If these linkages can be made, the DVBW will be hailed not only as a unique park in its own right, but also as a pivotal site in its role in moving the city closer to possessing a connected green space and healthy natural and cultural heritage systems.

The DVBW is not a true ecological "restoration" in that its ultimate goal is to achieve ecological integrity and serve no other purpose, nor does it claim to be. With the Don Valley Brick Works transformation from a brick making facility to a naturalized public park in the centre of Toronto, a combination of both restoration and reclamation is indeed necessary and timely. Although the ultimate purpose of reclamation and restoration may be fundamentally different, in application the final product lies somewhere along a continuum between the two fields. As time passes the vision of the DVBW park may change, but it will always need to serve both the public and the wildlife of the Toronto. Considering all the compromises that must be met in the urban environment, the DVBW is a prime example of planning for a combination of public use and regeneration.

Note

The opinions portrayed in this paper reflect the author's views and may not be those of the City of Toronto.

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